

**The syntactic representation and processing of nouns and verbs
in language production**

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'I think anybody who doesn't think I'm smart enough to handle the job is underestimating' (George W. Bush, 2000).

Declaration

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

Alexandra A. Cleland

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Abstract

Most current theories of language production assume that there are a number of distinct stages intervening between the generation of a preverbal message and its articulation, with stages of linguistic processing at semantic, syntactic, lexical and word-form representations. It is commonly assumed that these processes are separate and driven by lexical entries; for example as in the lemma model of lexical access (e.g. Levelt et al., 1999). While there has been much research into the processes underlying the semantic and phonological components of production, there has been less empirical investigation of syntactic processes, and in particular the nature of the syntactic representations that underlie production. This thesis presents an empirical investigation into the nature of syntactic representations and processing, based on syntactic priming (Bock, 1986). It focuses on a number of specific issues: how syntactic formulation is affected by time constraints, whether syntactic representations are accessed in the same way for written and spoken production, and to what degree semantic and phonological factors can affect syntactic encoding.

The finding that speakers have a tendency to reuse syntactic structure in consecutive utterances is replicated using a sentence completion task (Pickering & Branigan, 1998). In addition the research suggests that these processes can be altered when speakers are under time pressure. Further studies demonstrate that syntax is accessed in the same way for written and spoken production, consistent with an account where syntactic information is represented at a modality neutral level of representation. A dialogue task demonstrates that syntactic information is represented for nouns in a similar manner as for verbs, and that syntactic representations are likely to be shared between comprehension and production. In addition, further experiments show that semantic factors can influence syntactic encoding where phonological factors do not.

The results are interpreted as consistent with a model of production where information feeds forward from the semantic to the syntactic to the word-form levels. Syntactic information is represented at a modality neutral lemma level shared between comprehension and production, where multiple lexical representations receive activation from the semantic level but activation does not feed back from the word-form level of representation (e.g. Levelt et al., 1999).

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Chapter 1

Introduction and Literature Review

1.0 Overview

This chapter first provides an overview of the structure for the thesis, outlining the content of each chapter. It then provides a review of language production literature. First, I will review the common assumptions behind the major models of language production; that semantic, syntactic and word-form information are represented separately. Following an account of models of lexical access proposed by Levelt et al. (1999) and Dell (1986), some of the empirical evidence which supports these models is reviewed. Research concerned with the factors which influence a speaker's (or writer's) choice of syntactic structure is also reviewed, with a particular emphasis on the syntactic priming effect.

1.1 Thesis Overview

This chapter outlines the research which provides the theoretical and methodological basis for the research presented in the rest of the thesis. In particular, research on the factors influencing syntactic structure is reviewed, and the paradigm of syntactic priming introduced. Chapter 2 presents two sentence completion experiments which investigate how speakers react to being placed under time pressure. The results provide some tentative evidence that speakers are more likely to reuse syntactic structure when placed under time pressure, and also that they produce shorter utterances when under time pressure, consistent with the view that speakers act to reduce their formulation costs. Chapter 3 examines the degree to which syntactic processes overlap between writing and speaking, contrasting accounts where syntactic information is represented separately for orthography and phonology with accounts where syntactic information is shared between orthography and phonology. Three sentence completion experiments compare the magnitude of within and between modality priming, and the results suggest that syntactic information is shared between orthography and phonology. Chapter 4 investigates syntactic priming of noun phrase structures in a dialogue task using the confederate priming technique. The results demonstrate that speakers are likely to reuse noun phrase structures which they have just heard. This is consistent with

shared syntactic representations between comprehension and production, and suggests that syntactic information may be represented for nouns in a similar manner to verbs. In addition, two further experiments are reported which demonstrate that while semantic factors can affect the magnitude of the priming effect, phonological factors do not. This is interpreted in terms of a feedforward model of language production which does not allow feedback from the word-form to the syntactic level. Finally, Chapter 5 briefly presents the thesis conclusions.

1.2 Introduction

Between the generation of a preverbal message and its articulation, language formulation must proceed through a number of stages. While a speaker must know the message which they wish to express, the process of mapping this onto language is by no means simple. The speaker must be able to select the words they are going to use from their vocabulary, and an average speaker's vocabulary is vast; they will know somewhere in the range of 70 000 words, 30 000 of which they will choose from when speaking (Altmann, 1997). However, having selected the words they want to use, the speaker must be able to produce these in a sensible order, that is, an order which conforms to the grammatical rules of their language. They will have to organise their words based on grammatical category, and in the right order to convey who did what to whom. In addition, the form of the words they use will depend on factors such as the word's own tense (in the case of a verb), and also on the properties of other words in a sentence. Once a speaker has formed the syntactic structure of their sentence and the order in which their words will appear, and the tenses, and aspects and genders and so on of these words, they must have access to phonological forms (which may of course depend on the factors listed above). To finally utter a sentence, the speaker must be able to translate the phonological form of a word into the correct motor movements to produce the spoken word so that others can understand it.

The study of language production seeks to understand the process of formulation which intervenes between the generation of the speaker's preverbal message, and its articulation. Through the use of empirical techniques, researchers have been able to propose models of the processes underlying this complex process (e.g. Morton, 1969; Dell, 1986; Levelt, 1989; Shelton & Caramazza, 1999). Much of this

research has been based on failures of production. For example, speech errors have proved to be a useful source of data in determining different processing stages (e.g. Garrett, 1975, 1980; Dell, 1986), as has tip-of-the-tongue phenomena (e.g. Vigliocco, Antonini & Garrett, 1997) and the patterns of deficits in brain-impaired patients (e.g. Caramazza & Hillis, 1991). Other research has looked at what factors can interfere with a speaker's language production, for example in picture-word interference studies (e.g. Schriefers, Meyer & Levelt, 1990; Damian & Martin, 1999).

This thesis is most concerned with the processes underlying a speaker's choice of syntactic structure (e.g. Bock, Loebell & Morey, 1992; Bock, 1986b; Ferreira, 1996; Pickering & Branigan, 1998). In particular, it is concerned with the implications that these factors have for the representation of syntactic information. It is clear that speakers at some point access syntactic information; what is less clear is the nature of this representation. For example, it is not clear whether syntactic representations are shared between speaking and writing (Chapter 3), or whether the same syntactic representations are accessed for comprehension and production (Chapter 4). Another issue which has been of importance in the literature is the degree to which semantic and phonological factors influence syntactic processing (Chapter 4). In addition, the thesis examines whether the same kind of syntactic information is represented for different grammatical classes of words. An adequate model of language production must be consistent with all of these factors.

1.3 Models of Language Production

This section outlines the processes which it is assumed must underlie the transformation from a preverbal message to articulation, based on Garrett (1980; 1982; 1988) and expanded upon by others (e.g. Levelt, 1989; Bock & Levelt, 1994; Dell, 1986). Largely based on speech error data which suggest that grammatical and phonological processes operate in different ways, current models of language production assume a distinction between the processes underlying the selection of lexical concepts and the generation of a syntactic plan (termed grammatical encoding), and the processes underlying the selection of word-forms and the generation of intonation (phonological encoding) (e.g. Bock & Levelt, 1994). Fig. 1 provides an overview of these processes, based on proposals by Garrett (1980, 1982, 1988).

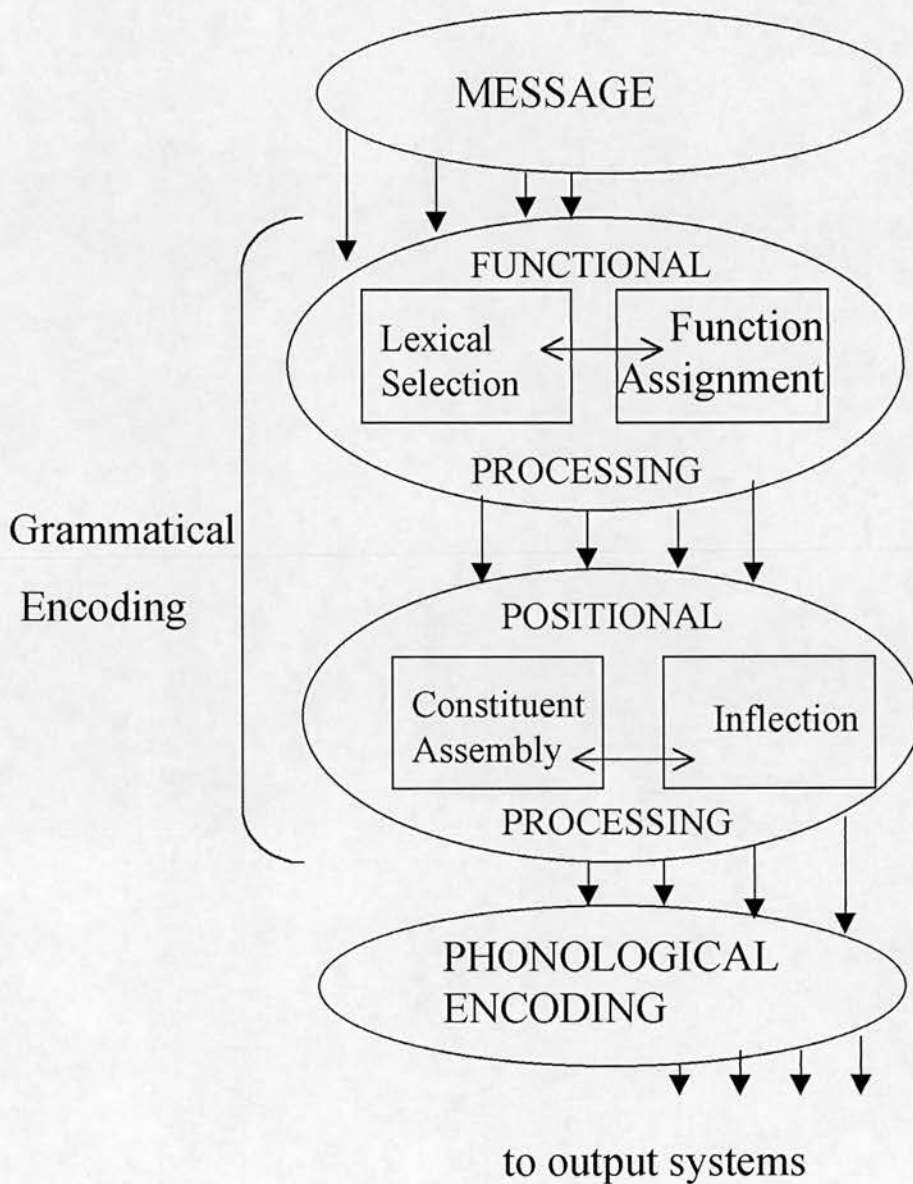


Fig. 1 Language production processes (from Bock & Levelt, 1994)

Grammatical encoding is broken down into functional processing and positional processing. Functional processing involves lexical selection and function assignment. Lexical selection refers to the process by which the words which will be used to express a message are selected from the array of possible words present in the mental lexicon. Function assignment involves assigning syntactic functions to these words,

for example whether the word will appear as the subject or the object in the final sentence. Positional processing involves assembling phrases, words and grammatical inflections into an order which is consistent with the grammatical specifications of the language. In other words, it will take the output of function assignment, and order these words. It is worth noting that while word order may in part be determined by function assignment, the same grammatical relations may sometimes be expressed through different word orders – it is positional processing which determines which of these is used. There is also a lexical component to positional processing as it involves retrieving an abstract representation of word-form which will be filled out during phonological encoding, and includes information about the morphology of the word.

These processes are likely to be lexically driven; some kind of representation of linguistic information must be a key factor in bridging the gap between these different processes:

... grammatical and phonological encoding are mediated by lexical entries. The preverbal message triggers lexical items into activity. The syntactic, morphological, and phonological properties of an activated lexical item trigger, in turn, the grammatical, morphological, and phonological encoding procedures underlying the generation of the utterance. The assumption that the lexicon is an essential mediator between conceptualization and grammatical and phonological encoding will be called the lexical hypothesis. The lexical hypothesis entails, in particular, that nothing in the speaker's message will *by itself* trigger a particular syntactic form, such as a passive or a dative construction. There must always be mediating lexical items, triggered by the message, which by their grammatical properties and their order of activation cause the Grammatical Encoder to generate a particular syntactic structure. (Levelt, 1989 p. 181).

However, the way in which different models of language production implement this differs. Arguably, the most important point of difference between these models is whether they assume that language production is a modular, feedforward process, or whether there is some degree of interactivity between levels of representation. I will concentrate on two contrasting models of production which reflect this. The first is the lemma model of lexical access proposed by Levelt et al. (1999), and the second is the model of access proposed by Dell (1986).

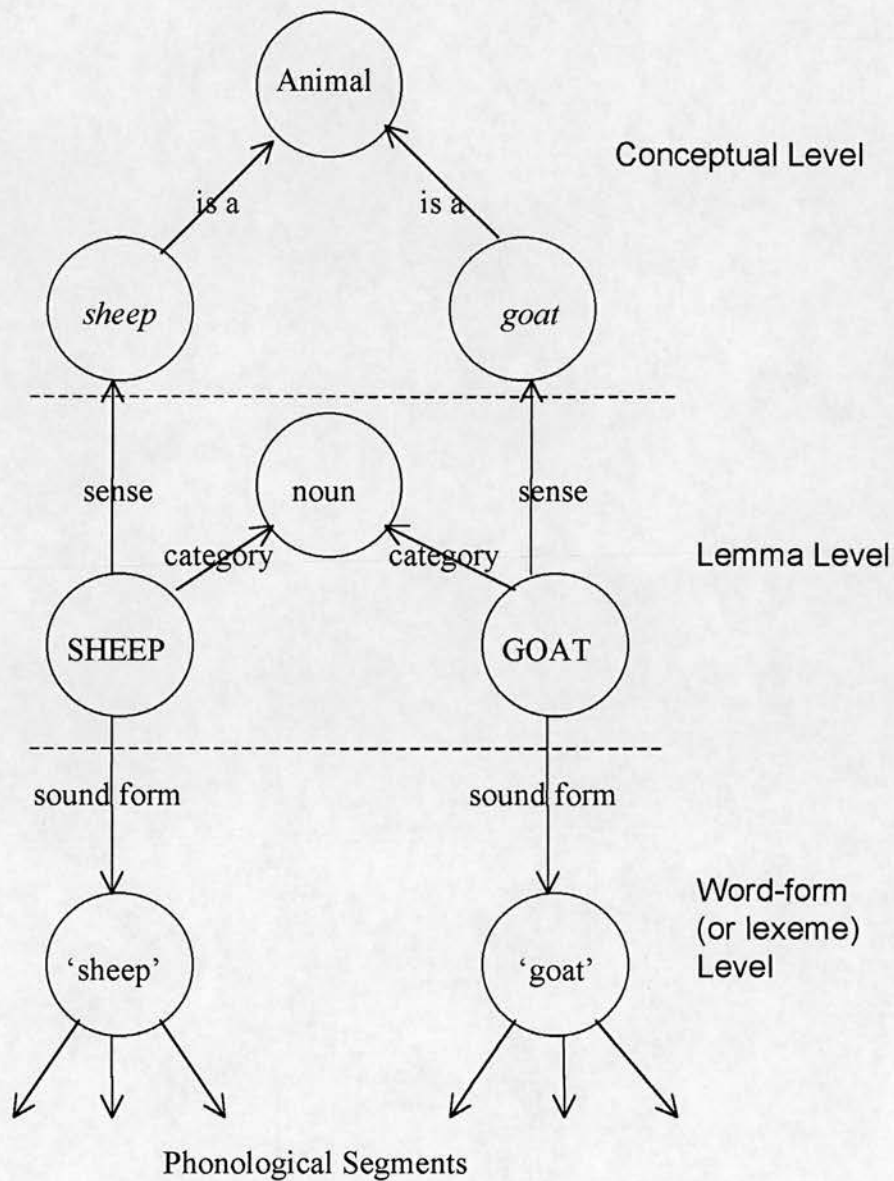


Fig. 2 Simplified representation of lemma model of lexical access (based on Levelt et al., 1999).

Arrows represent type of connection, not flow of activation

1.3.1 Levelt Model of Lexical Access

Fig. 2 outlines the lemma model of lexical access, based on Levelt et al. (1999). In this model there are three levels of representation: the conceptual, the lemma, and the word-form (or lexeme) level.

At the conceptual level, information relating to the meaning of a word is represented. In the network presented here, the lexical concept node *sheep* is linked to the conceptual nodes for semantically related lexical items, in this case, *goat*. These nodes are not specified for syntactic or word-form information.

The second level of representation is the lemma level, which can be thought of as corresponding to the process of grammatical encoding. It contains abstract representations of words which are not specified for word-form properties, but are specified for syntactic information such as grammatical gender and class; in addition for how the words might be combined with other units in a sentence. This unit has been termed a 'lemma' (from a term introduced by Kempen & Huijbers, 1983). So, in the example here, the lemma SHEEP is linked to information specifying that it is a noun. As part of functional processing, the lemma for a particular word will be selected during lexical selection, and so its corresponding syntactic properties will become available for function assignment and positional processing. In the model proposed by Levelt et al. (1999), lemmas do not represent semantic information, but do represent syntactic information; however other authors have suggested that lemmas are lexical representations that specify the meaning of a word and are organised into semantic fields (e.g. Butterworth, 1989; Zorzi & Vigliocco, 1999).

The third level of representation is the word-form level of representation, where word-form nodes, (or lexeme nodes) are linked to information regarding a word's phonological and morphological shape. This information is retrieved during phonological encoding.

The model described here operates on the assumption that activation feeds forward from the conceptual to the lemma to the word-form level. So, during production of the word 'sheep', the lexical node at the conceptual level for the concept *sheep* will become activated. It will also spread a degree of activation to the lexical concept *goat*, as *goat* is semantically related to *sheep*. Activation then feeds forward from the conceptual to the lemma level, so the lemma node SHEEP will receive the most activation, however, the lemma GOAT will also receive a degree of activation from its conceptual node. The likelihood of a specific lemma being selected is dependent on its degree of activation relative to the other lemmas, and so (in this case) the lemma SHEEP will normally be selected. As syntactic information is represented at the lemma level, its syntactic features will become available. Activation will then spread

forward from the lemma SHEEP to the lexeme 'sheep', and so the morphological and phonological properties of 'sheep' will become activated. Because words which are phonologically similar share information such as phonemes, lexemes for words which are phonologically similar (e.g. 'sheet') to 'sheep' may also receive a degree of activation. In a modular, feedforward model such as Levelt et al. (1999), there is no feedback from the lexeme to the lemma level. The process of lexicalisation, that is, the retrieval of a word for a to-be-expressed message, involves two distinct stages: one which involves retrieving the lemma, and another which involves retrieving its corresponding lexeme, broadly corresponding to the grammatical and phonological stages of encoding.

1.3.2 Interactive Accounts of Lexical Access

In a modular account of language production, lemma and word-form access are non-overlapping stages that operate on different inputs. Semantic but not phonological information is active up to the point of lemma access while the reverse is true during phonological access. However there are some problems with this assumption. For example, in the speech error data, it has been noted that there are a higher occurrence of mixed errors than would be expected by a modular model; there is an above chance ratio of speech errors that are both semantically and phonologically related to the target word (eg. Dell & Reich, 1981; Stemberger, 1985; Dell, 1990). These observations influenced the interactive model of lexical access proposed by Dell and colleagues (e.g. Dell, 1986; Dell, 1988; Dell & O'Seaghdha, 1992).

Interactive models do not differ from the modular accounts in that they assume lexical access proceeds through 2 stages. However, they propose that while there is largely more semantic activation during lemma access, and largely more phonological activation during phonological access, there is also a degree of activation of both semantic and phonological information during both stages (e.g. Dell, 1986, 1988, 1990; Mackay, 1987; Stemberger, 1985; Harley, 1984; Martin, Weisberg, & Saffran, 1989), hence the production system is seen as locally interactive. They generally propose parallel phonological encoding of multiple items, so an entire set of lemma nodes that has been activated on the basis of a pre-verbal message propagates some degree of activation to the phonological level. Interactive models

generally implement spreading activation from the phonological to the semantic-syntactic levels (although Humphreys, Riddoch & Quinlan, 1988 is an exception to this rule).

While it is not the only example of its kind, the Dell model of language production (e.g. Dell, 1986; Dell, 1988; Dell & O'Seaghdha, 1992) is one of the most influential interactive models. Similarly to the model proposed by Levelt et al., activation proceeds through at least three stages. The conceptual level represents conceptual features. When the conceptual features become activated due to some external input, they spread activation to the lexical level; here, nodes represent lexical items. (These nodes are also referred to as lemma nodes and are equivalent to the lemma nodes in the Levelt model of lexical access). Lexical items which share semantic features will therefore become activated, and eventually the most activated lexical node is selected. So, for example, the lexical nodes SHEEP and GOAT would be likely to be simultaneously activated during production of the word 'sheep' as they share many conceptual features. The lexical items additionally spread activation to the phonological level, where nodes represent words' phonological features. This model postulates cascaded activation; so in contrast to modular two stage theories, the phonological features of all the semantically activated lexical items will receive some activation (e.g. the phonological features of 'goat' will receive a degree of activation as well as the phonological features of 'sheep'). Crucially, activation can also spread from this phonological level back to the previous lexical level. The result of this is that a lexical node such as SHEET may become activated as it receives activation from the phonological features it shares with 'sheep'.

To summarise, while the Dell model of language production bears many similarities with the model proposed by Levelt and colleagues, it differs in that it postulates cascaded spreading of activation, and that feedback of activation occurs from later to earlier levels of lexical access.

1.3.3 The IN Model of Lexical Access

While the Levelt and Dell models differ on the exact details of lexical access, they both present a model of production where syntactic representations intervene between conceptual and word-form representations. However, this assumption has been challenged. Caramazza and colleagues have proposed a model (the Independent Network model of lexical access) in which access to word-form information is

not mediated by access to an intervening lemma level; instead, syntactic information is represented at the same level as modality-specific word-form information (e.g. Miozzo & Caramazza, 1997; Caramazza & Miozzo, 1997; Shelton & Caramazza, 1999). Further discussion of this model is postponed until Chapter 3, which deals with the differences between spoken and written production.

1.4 Experimental Evidence for Two Stage Models

This section reviews some of the evidence which has been cited to support the Levelt et al. (1999) and Dell (1986, 1988, 1990) models.

1.4.1 Speech Errors

A large part of the data which have been used to develop the model of language production outlined above came from the analysis of speech errors. As mentioned above, the incidence of speech errors is low considering the volume and rapidity of the language we produce. On analysing a corpus of 15,000 utterances, Deese found just 77 syntactic anomalies (Deese, 1984), and Heeschen (1993) encountered a similarly low proportion in German utterances. Lexical selection errors occur in under 1 per 1000 words, and sound errors come in at a staggeringly low 1 in every 2000 words (Bock & Levelt, 1994). Despite the rarity of speech errors, and given the absence of experimental data relevant to language production, early models relied upon observations of the patterns of speech error people produce (e.g. Dell & Reich, 1981; Fromkin, 1973; Garrett, 1975, 1980; Dell, 1986).

While there are numerous types of speech errors which can occur, those which are cited most often as the motivation for the distinction between grammatical and phonological encoding can be broadly divided into three categories (Bock & Levelt, 1994). These are: lexical selection errors or substitutions which involve producing the wrong word in place of another; blends, which involve producing a blend of two words which could have been involved in the message; and finally exchanges, where elements in a sentence are produced in the wrong position.

There are a number of different substitution errors which seem to occur. Sometimes, words which are produced in error are actually semantically related to the word which the speaker intended to produce,

or may even be semantically related to another word in the same sentence. An example such as 'I could stand on my nose' (where 'I could stand on my head' was intended in a conversation about sinus pain; Fromkin, 1973) appears to combine these elements. 'Nose' is semantically related to 'head', but it is also related to sinus pain. So, it may be that activation at the conceptual level of a number of related concepts could result in a number of lemmas becoming activated, and the wrong one being selected; in this case both the HEAD and NOSE lemmas are activated, and NOSE has become selected. In the case of words which are semantically related to another in the sentence, there may also be an element of the word being activated at the wrong time in production, so in this case, the lemma for NOSE may have been relevant at another point in the utterance but has become activated prematurely (this was probably more likely in this case as 'nose' will have received some activation due to its relation to 'head' already). Other substitutions involve words which are phonologically related to the intended word but do not appear to bear any semantic relation to the intended word (i.e. malapropisms, Fay & Cutler, 1977). An example of a phonological substitution would be 'white Anglo-Saxon prostitute' where 'white Anglo-Saxon Protestant' was intended (Fromkin, 1973). Fay and Cutler argued that substitutions of this type were a result of the wrong word-form being selected during phonological encoding. Hence, semantic and phonological substitution errors appear to reflect different processing stages in language production.

However, mixed substitution errors can also occur. In this case, a speaker produces a word which is both semantically and phonologically related to the intended word; for example, 'release the hostages unarmed' where 'unharmed' was intended (Fromkin, 1973). Moreover, there is evidence to suggest that these errors occur more often than would be expected by coincidence alone (Dell & Reich, 1981; Stemberger, 1983); this observation has proved to be an important element in debates over the precise nature of the language production mechanism (e.g. Dell & O'Seaghdha, 1992). Proponents of interactive models argue that, as in a modular model, semantic-syntactic and phonological factors should influence errors at different levels, a modular model would not predict an above chance level of mixed errors. In addition, aphasics produce a high occurrence of mixed error word substitutions (Best, 1996; Blancken, 1990). Interactive accounts are consistent with these findings, as words which are semantically and phonologically related to the target word will receive activation from both their semantic overlap with the

target word, and due to phonological feedback from the word-form level. Hence, this additional activation will lead to these lemmas being likely candidates for substitution errors. As a feedforward account does not postulate feedback from the phonological to the lemma level, Dell and colleagues have argued that the speech error data is more consistent with the interactive account than the feedforward account.

However, Levelt (1989) has argued that a monitoring system operates during production, which functions to detect errors which have arisen during the formulation process before they are produced. As the words produced in mixed errors are similar to the intended word both semantically and phonologically, Levelt has argued that the monitoring system is less likely to detect them than words which are either semantically or phonologically related to the intended word but not both. Hence, the feedforward account does predict that mixed errors would occur more often than would be expected, and is in fact consistent with this finding.

Blends (e.g. 'hegraines' where 'headaches' and 'migraines' have blended together, Fromkin, 1973) involve words which are near synonyms or equally appropriate given the message which the speaker is expressing. Accounting for blends is in fact more problematic than the other kinds of errors because while the final product clearly involves a phonological component, the words themselves must have both been selected at a conceptual level. It has been proposed that blends arise when there is a failure at the conceptual level to settle decisively on one way of expressing a message and therefore the system appears to be processing two different utterances in parallel, resulting in the merging into one final product (Butterworth, 1982; Garrett, 1980; Harley, 1984). So, the simultaneous activation of the lemmas HEADACHE and MIGRAINE has failed to lead to one of them being selected over the other.

The final type of speech error of interest here is when words or sounds exchange with one another within a sentence. Garrett (1975) proposed a distinction between word and sound exchanges, and it was this distinction which initially led to the separation of grammatical and phonological encoding processes (Bock & Levelt, 1994). In the first instance came the observation that speech errors predominately involved either words or phonemes, despite the fact that in actual fact, morphemes and features are more common in language. This implied that there were likely to be processes in language production implicated in finding and arranging words (in other words, grammatical encoding), and that

there must also be processes implicated in finding and arranging phoneme segments (in other words, phonological encoding). There also appeared to be a dissociation between the patterns of word and phoneme errors (Garrett, 1980). So, word exchanges tend to involve words which are from the same grammatical category, so nouns will exchange with other nouns (e.g. 'Seymour sliced the knife with a salami', Fromkin, 1973). In addition, the words involved tend to be separated by a number of words, even by a phrase, and syntactic features do not tend to exchange with the main word stems. So, in an example such as 'a hole full of floors' (where 'a floor full of holes' was intended, Fromkin, 1973), the utterance remains syntactically correct, despite the fact that the main stems of the words have swapped. The first noun remains singular, and the second remains plural.

In contrast, phoneme exchanges appear to operate independently of the grammatical class of the words involved, though they are likely to come from similar phonological categories and tend to involve adjacent words (e.g. 'blake fruid' where 'brake fluid' was intended, Fromkin, 1973). Not only does this add weight to the proposal that grammatical encoding and phonological encoding constitute different processes; it also suggests that they operate over different ranges. In terms of functional and positional levels, it supports a model where one level is concerned with the syntactic characteristics of the constituents of a sentence, and another is concerned with the structure of the phonological characteristics and the proximity of elements in the surface string.

To summarise, while this is a somewhat simplified account of the mass of speech error data available, it does demonstrate how the pattern of speech errors has been instrumental in the development of models of language production. They are still a major source of empirical evidence in debates over the exact nature of the language processing system (e.g. Dell & O'Seaghdha, 1992), and there is still no one account of how these errors occur.

1.4.2 TOT

The tip-of-the-tongue (TOT) phenomenon is the effect experienced when a speaker knows the word they want to produce but cannot manage to retrieve it from memory, despite the fact they may know syntactic or phonological information about it, creating a 'gap that is intensely active' (James, 1890; see

Brown, 1991 for a review). It appears that this TOT experience may be fairly universal among speakers (Reason, 1984), and often has an emotional component; some researchers have considered the emotional effect of TOT a defining feature of the TOT state (e.g. Gruneberg et al., 1973; Yarmey, 1973). Some investigations of TOT have involved asking people to record TOT experiences as they happen during everyday life (e.g. Burke et al., 1991, 1988; Reason & Lucas, 1984). However, others have tried to investigate the phenomenon in an experimental setting. In the first experimental study of TOT (Brown & McNeill, 1966), subjects were given dictionary definitions and asked to provide the word which the definition described. If the subject could not recall the word, but felt that they knew it, they were asked to provide any information they felt they did have access to. Brown and McNeill found that subjects often guessed the initial phoneme and number of syllables correctly, and when they provided other words that came to mind but were not the correct word, they often shared these features with the target word. It appears that speakers can have access to some phonological information while being unable to provide the word they have in mind. This has been taken as a failure in retrieving the lexeme, having retrieved the lemma; the speakers clearly know the word they are trying to produce, but do not have access to its word-form.

More recent investigations into the TOT phenomena have yielded stronger support for this interpretation. Vigliocco, Antonini & Garrett (1997) investigated the degree to which speakers in a TOT state have access to syntactic information. They presented subjects with definitions and asked them to provide the word that matched the definition. If the subject felt that they knew the word but could just not recall it, they were asked a series of questions on how well they felt they knew the word, what gender they thought the word was, how many syllables it had, what letters they thought it had and also to provide any other words that came to mind. Vigliocco et al. found that the subjects often had access to partial information about the word; most interestingly, they found that in over 80% of cases, subjects provided the correct grammatical gender for the word they were trying to recall. Vigliocco et al. concluded that this finding was highly supportive of a model which includes a stage of lexical access where syntax is represented independently from word-form information. In other words, the results were consistent with an account where the speaker in a TOT state has access to a word's lemma but not its lexeme.

Vigliocco, Vinson, Martin & Garrett (1999) investigated whether count and mass information was available to speakers in a TOT state and also an anomic speaker who experienced word retrieval difficulties. This relied on the distinction between 'count' nouns (e.g. mushroom) and 'mass' nouns (e.g. broccoli). The English speakers were presented with definitions or pictures and when they felt they knew the word but could not produce it were asked about what features of the word they did have access to. Vigliocco et al. found that the English speakers could accurately guess whether the word was a count or mass noun. The anomic speaker was similarly asked for information about definitions and pictures which he could not provide the word for although he felt he knew it. Again, he showed an ability to accurately guess whether the word he was trying to produce was a mass or count noun. These findings were important as, unlike grammatical gender in Italian, there is no phonological correlation with whether a noun is count or mass. In short, the finding that count and mass information was available without the word's phonological form is again supportive of a two-stage model of lexical retrieval, where the selection of an abstract representation specified for meaning and syntax (i.e. lemma) precedes the retrieval of the word's phonological properties.

The experience of anomic patients, as described by Vigliocco et al. (1999) (see also Henaff Gonon, Bruckert & Michel, 1989; Goodglass et al., 1976; Martin, Lesch & Bartha, 1999) is highly similar to that of normal speakers in a TOT state, and has similar implications for theories of lexical access. For example, Badecker et al. (1995) described an Italian anomic patient who was able to identify the grammatical gender of words which he was unable to produce the correct word-form for. This spared ability to retrieve syntactic information in the face of severe difficulties retrieving word-form information is again supportive of a model which postulates two stages of lexical access, one which represents syntactic information, and one which represents phonological information. In the case of these anomic patients, it appears that there is damage corresponding to the word-form or lexeme level, with preserved access to the lemma level.

It is worth noting that not all researchers have reached the conclusion that the TOT data are supportive of the lemma model; most notably Caramazza and colleagues (e.g. Caramazza & Miozzo, 1997; Miozzo & Caramazza, 1997) have questioned the conclusions drawn by Vigliocco and colleagues,

and have even provided TOT data which they argue is inconsistent with a lemma model. However, a fuller discussion of these studies will be postponed until Chapter 3, which deals with the Caramazza model of lexical access in more detail.

1.4.3 Event-Related Potential Studies

Event-related brain potential (ERP) recordings have been used to study the time course of language production (Van Turenhout et al., 1998; 1999; Schmitt et al., 2001). ERP recordings allow a very fine grained analysis of the time course of activation in the brain. Schmitt et al. (2001) used ERP recordings to investigate the time course of conceptual and syntactic encoding during picture naming. Participants viewed pictures and had to make decisions based on either conceptual features (whether the object was heavier or lighter than 500g) or syntactic features (grammatical gender). The lateralized readiness potential (LRP), which is a measure related to response preparation in the participant, and the N200, which is related to response inhibition, were assessed. Both gave results indicating that conceptual processing began approximately 80ms earlier than syntactic processing.

Van Turenhout et al. (1998, 1999) investigated the time course of syntactic and phonological processing in spoken production. Participants viewed pictures and had to make a syntactic-phonological classification. Based on the differences in the LRP data between the trials when syntactic information determined the response and the trials when phonological information determined the response, van Turenhout et al. concluded that syntactic information is retrieved 40ms before a word's initial phoneme. They argued that this implies that 40ms is needed to retrieve the initial phoneme after the lemma has been accessed.

Taken together, these ERP experiments are consistent with a model where access of word-form information follows access of syntactic information. In this sense, the results are consistent with a model of lexical access such as that proposed by Levelt et al. (1999) which postulates that syntactic information is represented separately from word-form information and intervenes between the conceptual and word-form representations.

1.4.4 Stroop-type Effects

Studies investigating the effect of distracting stimuli on word production can be thought of as variants of the Stroop task (Stroop, 1935). Typically, subjects are asked to name pictures, and distractor words are presented visually or auditorily (Rosinski, Golinkoff & Kukish, 1975). The automatic processing of these distractor words affects picture naming, and so the effect of different types of distractor can be assessed.

Semantically related visual distractors presented simultaneously with a picture-to-be-named result in slowed naming responses relative to the case where the distractor is unrelated to the picture (e.g. Rosinski et al., 1975; Lupker, 1979; Rosinski, 1977; La Heij, 1988; Underwood, 1976). This effect occurs if the distractor is a member of the same category as the picture; Lupker (1979) showed that there is no semantic distractor effect if the word is only semantically associated with the picture. Conversely, form related words speed up the naming of pictures. So, an orthographically related letter string (e.g. Posnansky & Rayner, 1977, 1978; Rayner & Posnansky, 1978) or word (e.g. Briggs & Underwood, 1982; Lupker, 1982; Rayner & Springer, 1986; Starreveld & La Heij, 1995; Underwood & Briggs, 1984) resulted in a quicker naming response than if the distractor was unrelated.

Glaser and Dungelhoff (1984) varied the presentation time of the distractor words relative to the presentation of the picture-to-be-named. By varying the presentation of the distractor, they could assess at what point in production the distractor affected language production processes; it follows that if a distractor causes an effect, then at that point in time, the language system must be processing information in some way related to that distractor. Glaser and Dungelhoff found a semantic interference effect at around 0 ms SOA, that is when there was 0ms between the presentation of the picture and the presentation of the distractor word (cf. La Heij, Dirkx, & Kramer, 1990). Studies investigating the effects of phonological distractors found effects ranging from SOA -200ms (i.e. 200 ms before picture onset) to +100ms (i.e. 100 ms after picture onset; e.g. Rayner & Springer, 1986). Meyer and Schriefers (1991) found that phonological distractors (presented auditorily) facilitated naming responses between -150ms and +150ms when their initial phoneme was related to the target word, and at 0 ms to +150 ms when their

final phoneme was related to the target word. They concluded that phonological encoding of the beginning of a word is initiated before the encoding of its end.

Schriefers, Meyer and Levelt (1990) used auditorily presented distractors to investigate the time-course of lexical access, as this method avoids the problem of determining whether facilitation effects were caused by orthographic or phonological characteristics of the distractor words. They found that there was an early effect of semantic interference on picture naming when semantically related words were presented early (-150ms SOA), whereas there was a later facilitatory effect of phonological distractors (0ms, +150 ms). Schriefers et al. concluded that there was a stage of lexical access at which only the meaning of a word was activated followed by a stage where only its form was activated. This is consistent with a feedforward model of lexical access, where there is no feedback between phonology and semantic levels of representation (e.g. Levelt, 1989; Levelt et al., 1999).

These Stroop type tasks have played a significant role in the debate over whether language production is a feedforward process, or whether there can be a degree of interactivity between the phonological and syntactic levels. Starreveld and La Heij (1995) found that the semantic interference effect was reduced when the distractor words were orthographically related to the picture's name (cf. Rayner & Springer, 1986). They argued that this suggested a degree of interactivity between the semantic and word-form levels (but cf. Roelofs, Meyer & Levelt, 1996; Starreveld & La Heij, 1996b). Starreveld and La Heij (1996a) found that the results depended on whether distractors were presented visually or auditorally; they found that visually presented distractors resulted in phonological effects preceding and following semantic interference effects in time; this stands in contrast to the results of Schriefers et al. (1990).

Levelt, Schriefers, Vorberg, Meyer, Pechmann & Havinga (1991) gave subjects a picture naming task. On some trials, subjects also completed a lexical decision task; so a probe word (or nonword) would appear after the onset of the picture. Subjects had to make a lexical decision to whether the probe was a word or not, and then name the picture presented. The probes were either semantically related (e.g. 'goat' whether the picture was a sheep), phonologically related (e.g. 'sheet') or mediated, that is phonologically related to a semantically related concept (e.g. 'goal', phonologically related to 'goat'). Levelt et al. argued

that mediated priming would be predicted by an interactive account, as the lemma 'goat' should be affected by the phonological prime 'goal' and hence should in turn affect the retrieval of the lemma 'sheep'. They based this on the argument that if the Dell model has its parameters set to explained mixed speech errors, then the same parameters would expect mediated priming. While Levelt et al. found effects of semantic and phonological primes, they found no effect of mediated primes. They concluded that the results supported a feedforward model of language production. However, others have found some evidence for mediated effects using different methods. Balota and Lorch (1986) found mediated semantic priming in naming but not a lexical decision task. McNamara and Altarriba (1988) observed mediated semantic priming in a lexical decision task, but only when it was not obvious that the pairs were related. In view of this, and given that they are arguing on the basis of a null result, Levelt et al.'s conclusions should be approached with some caution (cf. Dell & O'Seaghdha, 1991; but also Levelt, Schriefers, Vorberg, Meyer, Pechman & Havinga, 1991b).

Peterson and Savoy (1998) investigated the time-course of lexicalisation by presenting subjects with pictures to name. On some trials, a visual target word was presented following the picture, and the subject named the word. They found priming for target words which were related to the dominant name of the target pictures, as well as for those which were related to a near-synonymous name. They argued that this was consistent with a cascaded account, where multiple lexical items receive phonological activation during production. As the debate over feedforward versus interactive accounts of language production has tended to centre on whether there is feedback between levels rather than the issue of whether cascaded processing occurs, Peterson and Savoy could not conclude that their results supported one account over the other. The model of language production proposed by Dell (1986) assumes cascaded processing and so is consistent with these findings. It is less clear whether a feedforward account of production as proposed by Levelt et al. is inconsistent with this; Levelt et al. (1991) rejected the cascaded processing view. However, despite this, a cascaded model of processing is not necessarily inconsistent with a feedforward account. At the least, Peterson and Savoy argued that modular accounts needed to clarify the nature of the mechanisms underlying the feed forward of activation through the system.

Damian and Martin (1999) found an interaction of phonological and semantic relatedness. During a picture naming task with simultaneously presented visual or auditory distractor words, there was a semantic interference effect which was attenuated when the distractor was phonologically related as well as semantically related to the target word. In this case, the presentation of the visually presented words was fixed, so that they were more similar to auditory distractors in terms of presentation time. Damian and Martin found that these distractors yielded an effect. They argued, based on the pattern of their results, that there was a good case for allowing at least some interactive feedback between representational levels, contrary to a strictly feedforward approach.

Interference effects have also proved to be informative as to the production of sentences. For example, Meyer (1996) investigated the degree to which elements in a sentence are encoded before speech onset. In a series of experiments, subjects were asked to name pictures that depicted two objects producing them in a left to right order. In some experiments they produced these in the form 'x and y'; in others, they produced sentences of the form 'x is next to y'. Meyer examined the effect of distractor words which were semantically or phonologically related to the first or second noun, and controlled when they were presented relative to the stimulus onset. She found a semantic interference effect for both of the nouns in the picture when the distractors were presented 150 ms before or simultaneously with the picture presentation. This suggested that both lemmas had been selected before speech onset. However, while there were strong facilitative effects of a phonological distractor when it was presented at or up to 300ms after picture onset, this only occurred for the first noun in the sentence. No facilitation effects were found for the second noun. This suggested that while the first noun was phonologically encoded before speech onset, the second noun was not. Meyer argued that the results supported a model of language production where the lemmas and word-forms are stored separately in the lexicon, and the lemma of a word can be selected without its form (cf. Schriefers & Teruel, 1999 for phonological facilitation effects in 2 word utterances). Schriefers, Teruel and Meinhausen (1998) investigated the degree to which verbs were encoded before speech onset using a broadly similar technique, and concluded that the verb is not necessarily part of the grammatical advance planning unit for finite clauses. In addition, there is some evidence of gender interference effects in noun phrase production (Schriefers & Teruel, 2000).

To summarise, Stroop type effects in language production have proved to be informative about the time course of language processing, perhaps most interestingly in relation to the modularity debate. Presently, it appears that the evidence may be weighted in favour of an account of production which allows at least a degree of interaction between different levels of representation, ‘globally modular but locally interactive’ (Dell & O’Searghda, 1991).

1.5 Syntactic Processes in Language Production

There are a number of processes that the language production system has to be able to compute during language production. For example, the system must compute gender and number agreement. Some research in language production has investigated the role of agreement processes (e.g. Bock & Miller, 1991; Vigliocco, Butterworth & Garrett, 1996; Bock, Eberhard, Cutting, Meyer & Schriefers, 2001). Others have investigated the role of grammatical gender in syntactic processes (e.g. Schriefers & Jescheniak, 1999) or frequency effects (e.g. Jescheniak & Levelt, 1994) as a route to understanding the nature of syntactic representations. However, this thesis is primarily concerned with the factors affecting word order in production, and how this can inform us of the syntactic representations underlying lexical access. The next section reviews some of these factors before the last section focuses on syntactic priming literature in more detail.

1.5.1 Factors Affecting Word Order

Frequently, more than one syntactic structure can be used to express a given message; in this sense, language is syntactically flexible. So, for example, the sentences ‘The cricketer shows the ball to the umpire’ and ‘The cricketer shows the umpire the ball’ express essentially the same message; however, they differ in syntactic structure. The former takes the form of a prepositional object sentence (PO), the latter a double object sentence (DO). Likewise, ‘The cowboy shot the sheriff’ and ‘The sheriff was shot by the cowboy’ (active and passive structures respectively) describe the same event, but have different syntactic structures. At some point, the production system must ‘decide’ which structure it is going to use

In some cases, the word order a speaker selects may be influenced by the speaker focussing on an object of interest (e.g. Tannenbaum & Williams, 1968). However, on other occasions, it is less clear what has led the speaker to produce one syntactic structure rather than another; this section reviews what factors can influence this choice.

There is a degree of correlation between the features of a noun, and its position in a sentence. So, for example, nouns which are the subject of a sentence are likely to be more animate (e.g. Clark, 1965), more concrete (e.g. Clark & Begun, 1971) and more salient (e.g. Osgood & Bock, 1977) than nouns which are the object of a sentence. These are features which it has been suggested reflect these word's greater accessibility, in other words how easily available it is to the language production system. Much research into word order has investigated the effect of accessibility on a speaker's choice of syntactic structure and word order (e.g. Bock, 1982, 1986a, 1987; Bock & Irwin, 1980). In an early example of work of this kind, Osgood (1971) presented participants with a sentence description task and found that entities which appeared in more than one successive picture were mentioned earlier in the participant's sentences; so, entities which are 'given' rather than 'new' appear to assume prominent syntactic positions. However, Bock and Irwin (1980) showed that this effect was reduced when the words introduced in a prior context were synonyms of the words used in the target sentence. It appeared that some of the apparent effects of given-ness could be due to lexical priming rather than due to non-linguistic influences on syntactic structure.

Levelt and Maassen (1981) investigated the effect of lexical accessibility on word order. They asked participants to describe moving arrays of objects, and manipulated the lexical accessibility of the words the participants produced. They did this by asking the participants to produce allonyms for the objects on some trials; so, for example, they might be asked to use the word 'roof' to refer to a triangle. Levelt and Maassen argued that this would render lexical search more difficult, and so the word would be less 'lexically accessible'; of interest was whether allonyms would appear later in the speaker's sentences than the other, more lexically accessible words. They found that lexical accessibility did not affect word order, in other words, allonyms were not more likely to appear later in the subjects' sentences. Levelt and Maassen proposed that in speech production there is no feedback from lexicalisation processes to

linearisation decisions. So, they proposed a dual relation between syntactic and lexical decisions whereby order of mention decisions at the functional level preceded linguistic decisions at the positional level. Having selected a syntactic frame, speakers went on to retrieve lexical information and there was no feedback from one to the other.

Whereas Levelt and Maassen (1981) had investigated the effect of lexical accessibility on word order, Bock and Warren (1985) investigated the role of conceptual accessibility. The imageability of the words which participants produce in a sentence recall task was manipulated, as Bock and Warren argued that words which were more imageable would be more conceptually accessible (e.g. James, Thompson & Baldwin, 1973). On recalling sentences, participants tended to place more imageable objects as the subject in declarative sentences, and as the direct objects in dative sentences; in other words, the more conceptually accessible words were placed earlier in the sentence than the less conceptually accessible words. In addition, speakers tended to change the structure of the declarative and dative sentences to allow this to occur. However, this effect did not occur when they recalled these words as part of a conjunctive phrase (e.g. 'winter and time'). Bock and Warren argued that given that the imageability, or conceptual accessibility of the words only affected word order when they involved grammatical roles, as in the case of dative and declarative sentences where the word must be assigned to either the subject or object, or direct or indirect object, the locus of the conceptual accessibility effect must be the functional rather than the positional level. Had the locus of the effect been the positional level, then an effect would have been predicted in the case of the phrasal conjuncts, where the nouns do not differ in grammatical assignment. Bock and Warren argued that conceptual elements in a sentence are assigned to roles in a relational hierarchy, such that the most accessible constituents are mapped onto subject roles, then the next onto direct objects and so on through the sentence. Hence, conceptual accessibility can have an effect on the speaker's choice of syntactic structure.

Using a similar method, Kelly, Bock and Keil (1986) found that prototypical category members were placed before less prototypical category members in a sentence recall task, and that the structures of sentences were changed so that this could occur. So, for example, participants were likely to produce 'iron' before 'nickel' in a sentence. In contrast to Bock and Warren, Kelly et al. found that this effect

influenced word order in phrasal conjuncts more than in declarative sentences. In other words, unlike imageability, prototypicality affected word order when the grammatical roles of the words involved were the same. This implied that, at least to some extent, the locus of the effect was the positional level. This raises the question of whether the conceptual accessibility, or the accessibility of the words themselves was affecting word order. It may be that the conceptual accessibility of the words was the source of the word order effects. However, another possibility is that words which were more prototypical were lexically more accessible, resulting in earlier positions in the sentence. Part of the problem with the Kelly et al. experiment was the difficulty over whether prototypicality reflects conceptual accessibility, when it must also to some extent reflect word retrieval. Wingfield (1968) found that prototypical entities (or at least common entities) were not recognised faster than nonprototypical objects; Kelly et al. point out that this may reflect the fact that prototypical entities are not in fact more conceptually accessible than nonprototypical entities. Oldfield and Wingfield (1965) found that the time required to name an object was inversely proportional to the frequency of its name. This suggests that the results observed by Kelly et al. may have been due to lexical accessibility rather than conceptual accessibility. However, in either case, Kelly et al. demonstrated that the serial position in a sentence (and, to some extent, grammatical roles) can be influenced by the accessibility of the entities in the sentence.

While the Bock and Warren and Kelly et al. experiments tried to use the 'inherent' accessibility of the words the speakers produced (Prat-Sala & Branigan, 2000), Bock (1986a) chose to manipulate the accessibility of words by using primes. This avoided the problem of defining what features of a word actually constitute 'accessibility'. In the Bock experiment, participants described pictures, with their descriptions preceded by the presentation of prime words. These primes were semantically or phonologically related to a target word likely to appear in the participant's description of the subsequent picture. So, for example, a picture of a cow kicking a horse could be preceded by a prime semantically related to one of the concepts (e.g. 'milk') or phonologically related (e.g. 'now'). Semantically primed targets tended to appear as the subjects of the active and passive sentences in the participant's descriptions. Conversely, unprimed words were more likely to appear as the object of a sentence. However, the phonological primes did not appear to have an effect on the word order of the speaker's

utterances. Bock argued that, while semantic accessibility could affect syntactic role assignments for words, phonology did not play a role in assignment of grammatical roles (consistent with a model of language production such as Levelt, 1989). In Bock's account of the data, assignment followed a hierarchical path, with the subject being assigned first, then the direct object and so on.

However, Bock (1987) did find some evidence for an effect of phonological accessibility on word order. Bock (1986a) does not provide an appendix, but in the examples given, the degree of phonological overlap between prime and target words appears to be relatively low (e.g. 'torpedo' and 'tarpaulin'; 'missile' and 'mason'; 'devil' and 'driver'). Using a similar paradigm, but with phonological primes overlapping with target words on initial phoneme (e.g. 'lamb' and 'lamp'; 'cat' and 'cap'), Bock (1987) found that words which had been phonologically primed were placed later in a sentence than words which were not. This appears to be incompatible with the account of Bock (1986a) where she argued that phonological factors did not affect syntactic formulation, and supportive of an interactive model of language production (e.g. Dell, 1986). However, on the basis of a dysfluency analysis which showed that there were more hesitations, filled pauses and false starts on the phonologically primed trials, Bock argued that feedback was not the cause of the effect. Instead, she argued that having already assigned syntactic form, subjects on the phonologically primed trials found that they had difficulty retrieving the phonological form of the word they wanted to produce at the positional level and so had to go back and revise their syntactic structure at the functional level. This was due to an inhibitory effect of the phonological primes on the word-form of the related word.

McDonald, Bock and Kelly (1993) investigated the degree to which animacy, word length and prosody affected word order. They argued that animacy was related to conceptual accessibility, whereas word length was related to facilitation of language processing (Zipf, 1949) and prosody was related to ease of production rather than ease of retrieval. They found that animate nouns tended to assume the subject position in a sentence during a recall task; however, they did not tend to be produced earlier in a conjunctive phrase within a sentence. This was consistent with the conclusions of Bock and Warren that the effect of animacy was located at grammatical role assignment rather than computation of serial word order. McDonald et al. did not find consistent effects of word length on word order, but did find that in a

judgement task, judges preferred short words to precede long words. They argued that conceptual factors were a dominant factor in the computation of word order. In addition, they argued that there may be some differences in accounts of word order for comprehension and production, given the fact the speakers expressed no preference for word length but comprehenders did.

Prat-Sala and Branigan (2000) drew a distinction between the ‘inherent accessibility’ of a word, as denoted, for example, by animacy, prototypicality and imageability, and a word’s ‘derived accessibility’. They defined ‘derived accessibility’ as a word’s accessibility relating to its saliency in a given discourse. Participants listened to a story which mentioned two entities, and then described a picture involving both of the entities. While both of the entities were ‘given’ in that they both appeared in the preceding story, one of them was made more salient because it was introduced after ‘There was’ and ‘this’, was mentioned first, was preceded by adjectives and had more properties predicated of it. Prat-Sala and Branigan used this technique with both Spanish and English speakers. Spanish provides an interesting case, as it allows the dislocated active structure, where the agent appears as the subject of a sentence, yet is preceded by the patient. So for example, a speaker might produce ‘to the woman ran over the train’, where ‘train’ is the agent, and ‘woman’ is the patient, yet their orders are reversed from a ‘normal’ active sentence. Prat-Sala and Branigan found that in the participants’ subsequent picture descriptions, salient entities were placed in more prominent syntactic positions in both English and Spanish sentences. Speakers were more likely to produce an active description when the agent was salient, and a passive description when the patient was salient. In addition, Spanish speakers produced more dislocated active descriptions after the patient-salient context. While there was therefore an effect of derived accessibility, this effect was also mediated by the word’s inherent accessibility; participants produced more passive and dislocated actives when the patient was both salient and animate than when it was salient but inanimate. This suggests that both derived and inherent accessibility play a role in word order decisions.

The fact that Spanish speakers were more likely to produce dislocated actives after a patient-salient context suggested that the locus of the effect was computation of word order rather than grammatical assignment; as both normal actives, and dislocated actives involve the same grammatical assignments. An account such as that proposed by Bock and Warren where the effects were located at

grammatical role assignment is not consistent with this pattern of results. Prat-Sala and Branigan instead argued that the results were compatible with an account where language production is incremental and conceptual accessibility can influence word order directly (e.g. Levelt, 1989). This is compatible with an account where speakers make use of syntactic flexibility to access more easily retrievable information before less easily retrievable information.

While these studies investigated the accessibility of nouns, either through manipulating their inherent accessibility (e.g. Bock & Warren, 1985) or by altering their accessibility temporarily (e.g. Bock, 1986a, Prat-Sala & Branigan, 2000), F. Ferreira (1994) investigated the role that features of the verb could play in the word order of a sentence. Participants were given two nouns and a verb and asked to produce a sentence involving all 3 words. Ferreira manipulated whether the verb they were presented with was 'normal', that is, an agent-theme verb (e.g. 'Mary kicked the table'), or an experiencer-theme verb (e.g. 'Bill feared the mugger') or whether it was a theme-experiencer verb (e.g. 'Bill amazed Tom'). The crucial difference between the 'normal' and theme-experiencer verbs was that in the normal verbs the subject of the sentence is the arbiter, or experiencer of the action and with the theme-experiencer verbs it is the object of the sentence who experiences an action. For example, Mary kicks and Bill fears, but it is Tom who is amazed. Hence, in the normal verbs it is the subject that is thematically prominent, and in the theme-experiencer verbs it is the object that is thematically prominent. Ferreira found that passives occurred more frequently with theme-experiencer verbs than with normal verbs; the speakers were using a different structure for their utterances so that the most thematically prominent entity appeared first in the sentence. She argued that sentences tend to be constructed in such a fashion that more thematically prominent entities occur in syntactically more prominent positions. This result was interesting, because while the sentences produced all contained the same elements (i.e. two nouns and a verb), properties of the verb resulted in the nouns assuming different syntactic roles. Hence, this demonstrated another factor which could influence speakers' choice of word order.

The consensus from this research appears to be that more accessible words assume more grammatically prominent roles. In this sense, syntactic flexibility may be of benefit to the speaker in terms of processing costs; it allows those elements that are most available to be placed first in a sentence. V.

Ferreira (1996) tested this incremental account of word order in contrast to a competitive account. According to an incremental account, the structure of an utterance emerges as the sentence is constructed; the elements in a sentence which are accessible at a given point in production will be placed first in a sentence hence influencing syntactic structure. However, according to a competitive account of production, alternative structures compete to determine which structure is eventually used, so for example, in a ditransitive utterance, both the plans associated with a PO and a DO structure will become activated and the most highly active will be produced. In view of this, Ferreira argued that a competitive account would predict that syntactic choices would present difficulties for the production system, as a choice between 2 alternatives was presented. In contrast, he argued that an incremental account should allow more fluent production, as the system places the most accessible elements earlier in a sentence and hence the syntactic structure is determined as part of production. Subjects were given a set of words, and asked to construct a sentence out of them. On some trials, the words included an alternator verb (e.g. 'give') which can appear with either a PO or a DO structure, and on other trials the words included an alternator verb (e.g. 'donate') which can appear with only one or the other, in this case the PO form. So, given an alternator verb, the speaker was faced with a syntactic choice between the PO and the DO form, but with a non-alternator verb they were restricted to either the PO or the DO form. This effect was also manipulated by presenting the word 'to' as one of the words to be included; on these trials, subjects had to produce a PO utterance, as a DO structure does not involve production of the word 'to'. Ferreira found that speakers produced an utterance more quickly and with less errors when constructing a sentence allowed syntactic choice; so, for example, subjects were quicker to produce a sentence involving the word 'give' than with 'donate'. He argued that this was consistent with an incremental account of language production, where the most accessible units in a sentence are produced first, rather than a competitive model where alternative syntactic structures compete during production (cf. Prat-Sala & Branigan, 2000).

The majority of these experiments were concerned with the accessibility of words in a sentence and how this might affect, or even drive, a speaker's choice of syntactic structure. However, there appear to be effects which cannot be explained solely in terms of an incremental model of language production. Prat-Sala and Branigan found that in English and Spanish, speakers had a general preference for actives

rather than passives. In addition, speakers of different languages have different preferences for which structure they tend to use (e.g. Bates & Devescovi, 1989). Stallings, MacDonald and O'Seaghdha (1998) found that speakers were more likely to produce a 'shifted' structure (e.g. 'Snowball had found in the harness-room an old green table cloth of Mrs. Jones') when the shifted noun phrase was relatively long. However, they also found that the frequency with which a verb could appear with a sentence structure in which it was not adjacent to its complement (e.g. as in 'Mary learned yesterday that she would be allowed to go hiking') affected how likely it was to be produced in a shifted structure. This effect of 'shifting disposition' suggests a competitive component to choice of syntactic structure.

Clearly, there are a number of factors which contribute to syntactic choice. While there is evidence of an incremental element to syntactic choice (e.g. Ferreira, 1996), overall preferences for certain structures have been interpreted in terms of a competitive model, based on the relative activation of different structures (e.g. Bates & Devescovi, 1989). The accessibility of the words and concepts involved in an utterance can influence syntactic structure; however other factors may also play a role. In fact, there is ample evidence that as well as the general preferences of a given language, a speaker's choice of syntactic structure can be influenced by the syntactic structures which they have previously processed; this is known as the syntactic priming effect.

1.5.2 Syntactic Priming Effects

The term 'priming' in general refers to the phenomenon whereby processing one stimulus can have a facilitatory (or inhibitory) effect on subsequent processing of related stimuli. So, for example a word which has recently been preceded by a semantically related word is quicker than an unprimed word (e.g. Meyer & Schvaneveldt, 1971). In this case, the priming effect was taken to have implications for the categories into which items are organised. In the case of syntactic priming, the facilitation of a syntactic structure is assumed to have implications for the grammatical processes and syntactic representations underlying language production or comprehension.

There is limited evidence of syntactic priming in language comprehension (e.g. Frazier, Taft, Clifton, Roper & Ehrlich, 1984; cf. Branigan, Pickering & Stewart, 1995). Frazier et al. found some

tentative evidence that sentences were comprehended more quickly when preceded by sentences of a similar syntactic structure. However, syntactic priming in comprehension has not convincingly been shown (Branigan, Pickering, Liversedge, Stewart & Urbach, 1995), and the majority of research has been in production-to-production, and comprehension-to-production priming.

There is a tendency towards repetition in natural dialogue, and while much of this is undoubtedly lexical in nature, there is some evidence of repetition of structure in dialogue (e.g. Schenkein, 1980; Tannen, 1984, 1989). In a corpus analysis, Weiner and Labov (1983) found that a significant predictor of a passive utterance was the presence of another passive utterance in the previous five utterances; up to 70% of passive utterances were in close proximity to a preceding passive. Estival (1985) went to some effort to try and isolate the factors which might contribute to this effect; however, it is difficult to define what exactly is causing this apparent syntactic repetition. For example, lexical or metrical priming may result in a repetition of syntactic structure without any syntactic processes necessarily being a source of the repetition. Similarly, repeated use of the passive utterance, as observed by Weiner and Labov (1983) may be a result of a conversation developing a very formal register, which is associated with high use of the passive structure.

Levelt and Kelter (1982) investigated the repetition of surface form using a question-answer paradigm in a number of settings. For example, they asked subjects questions about pictures, choosing to word the questions with either a prepositional or non-prepositional form, and found that subjects' responses tended to mirror the form of the question. For example, having been asked a question in the prepositional form (e.g. the Dutch equivalent of 'To whom lets Paul his violin see?'), the subject would be likely to answer with prepositional form ('To Toos'). Alternatively, had they been asked 'Whom lets Paul his violin see?', they would show a tendency to respond simply 'Toos'. In another, more naturalistic, experiment, they telephoned Dutch shopkeepers and asked questions about what time their shop closed; again, they found that the answerers repeated the surface form of the questioner's utterance. Subjects appeared to have a preference for question-answer pairings which corresponded in prepositional form; they rated them as more natural than those that did not. Levelt and Kelter had confirmed the previous observations that speakers have a tendency towards repetition in dialogue. They argued that retaining the

surface form of an utterance may have two main benefits. One was that it might aid understanding of incoming speech, another was that reusing syntactic form might reduce the processing costs of language production; it enabled a speaker to merely reuse a syntactic structure, rather than generate the structure from scratch for each utterance.

In a seminal paper, Bock (1986) provided the first experimental evidence of syntactic priming. Under the pretence of a memory test, subjects were asked to produce a prime sentence which could take one of several syntactic forms. They were then presented with an unrelated picture which they had to describe. Bock found that the subject's picture description was more likely to take the same syntactic form as the prime sentence than the alternative syntactic form. This occurred with ditransitive and active and passive structures. For example, a picture description such as 'The man is reading a story to the boy' (PO structure) was more likely had it been preceded by a PO prime (e.g. 'A rock star sold some cocaine to an undercover agent') than if it had been preceded by a DO prime (e.g. 'A rock star sold an undercover agent some cocaine'). Similarly, an active description was more likely following an active prime, and a passive following a passive prime (e.g. 'One of the fans was punched by the referee' vs. 'The referee punched one of the fans'). This appeared to be a syntactic effect as the prime and target sentences were not semantically linked to one another. Further experiments ruled out that the orientation of the pictures had contributed to the effect. Bock termed the effect 'syntactic persistence' and concluded that syntactic processes are at least to some extent isolable from conceptual processes. She hypothesised that the effect was due to the activation of information corresponding to the formation of grammatical structures in sentence production.

Subsequent research supported the conclusion that this was a syntactic effect. For example, Bock (1989) showed that priming occurred between PO sentences regardless of the prepositions in the prime and target sentences. So, for example, 'the secretary baked a cake for her boss' was as effective as 'the secretary took a cake to her boss' in priming another PO sentence. This suggested that the repetition effect was not due to the repetition of the preposition 'to'. Bock and Loebell (1990) ruled out the possibility that repetition was due to conceptual similarity between the prime and target sentences. They found that 'the 747 was alerted by the control tower' was as effective a passive prime as 'the 747 was landed by the control tower', despite the conceptual dissimilarities between the two. In addition, they ruled out that

metrical properties of the sentences or the phonological forms of the closed class words were leading to an apparent syntactic repetition. While 'Stella brought a book to Susan' and 'Stella brought a book to study' are similar in terms of the subject noun phrase, metrical structure and in phonology and positioning of closed-class words, they differ in constituent structure. Importantly, while the former was an effective prime for another PO sentence, the latter was not. Bock and Loebell concluded that the locus of priming was likely to be the processes associated with assembling and retrieving a syntactic frame's component structures, and that the priming effect could be due to a tendency to retrieve similar fragments or phrase structures from a fragment store.

Bock, Loebell and Morey (1992) used priming to investigate the relationship between function assignment and constituent assembly. Function assignment and constituent assembly reflect processes during functional processing and positional processing respectively (see Fig. 1, which shows how these labels map into one another). Bock et al. manipulated the animacy and syntactic structure of prime sentences. As well as replicating the finding that actives were more likely following active primes and passives more likely following passives, they found that inanimate subjects were more likely following primes with inanimate subjects. They argued that the former effect was due to constituent assembly being likely to produce the same structure in subsequent utterances and the latter was due to reusing the previous mapping of animacy to syntactic function during function assignment. Hence, the findings supported the view that function assignment and constituent assembly are separable processes.

While these experiments involved spoken production-to-production priming, Pickering and Branigan (1998) investigated production-to-production priming using a written sentence completion technique. Subjects were given a written task which involved completing sentence fragments. Prime fragments were worded such that subjects were likely to complete them using certain structures; for example, 'The racing driver showed the helpful mechanic ...' was likely to result in a DO completion, whereas 'The racing driver showed the torn overall...' would be likely to result in a PO completion. Target fragments which could be completed using either construction (e.g. 'The patient showed...') were more likely to be completed using the same syntactic structure as the prime than with the alternative. Pickering and Branigan found that the tense, number or aspect of the verb did not affect the magnitude of

priming; however, priming was enhanced when the verb was repeated between prime and target compared to when the verb differed between prime and target. They interpreted the results in terms of a lemma model of lexical access (e.g. Levelt et al., 1999), and argued that the priming effects might be driven by the nature of the representation of syntactic information at the lemma level. More specifically, they argued that words were linked to combinatorial information at the lemma level. For example, as well as being linked to representations specifying information such as grammatical class, a word such as 'give' would be linked to nodes which specified rules as to how it might be combined with other words in a sentence. Having produced a sentence of one structure, residual activation of the combinatorial node might result in the system reusing that structure in a subsequent sentence. As priming was enhanced when the verb was repeated between prime and target, Pickering and Branigan argued that this effect was due to activation of the links between the nodes as well as the nodes themselves. For example when the prime and target both contained the verb 'give', the residual activation of the link between the 'give' node and the combinatorial node would result in stronger priming than when the target contained the verb 'hand'. In addition, the lack of an effect of tense, number or aspect on priming suggested that these features did not form part of the lemma node, and that combinatorial information was represented for an unspecified form of the verb.

Using a method based on Bock (1986), Hartsuiker and Kolk (1998) found priming for the DO, medial dative (a Dutch structure roughly equivalent to 'the woman gives to the man the paintbrush') and passive structures. Hartsuiker and Kolk also measured baseline data; that is they examined the relative frequencies of the different structures in sentences preceding the primed trials. Interestingly, they found that the proportion of ditransitive structures was lower in the baseline condition than it was in any other condition; subjects were more likely to produce the target structures during the experiment than they were in the preliminary baseline condition. They labelled this effect 'long term priming' and argued that, every time a prime sentence of a certain structure was produced, there was an increased likelihood of that structure being used in the long term, regardless of a preference for a structure on any single trial.

Hartsuiker, Kolk and Huiskamp (1999) investigated the word order of sentences with structures like 'On the table is a ball' and 'A ball is on the table' in Dutch. They found a priming effect for these structures, in that the structure of the subjects' target sentences was influenced by the structure of the

prime, and also in terms of a long term priming effect. Hartsuiker et al. noted that the entities in the different prime sentences had the same functional and hierarchical relations, but differed in word order. In sentences of this type, the final word order of a sentence is not constrained by functional or hierarchical relations. Therefore the locus of the priming effect could not be the output of functional processing. Hartsuiker et al. argued that the priming effect supported the notion of a linearization process which operates on a constituent structure not specified in terms of word order. They argue that this linearization process would aid fluency as its incremental nature would be efficient. So, they interpreted the priming of word order as being due to the persistence of the constituent structure linearization process.

Using a sentence completion technique for both written and spoken production, Hartsuiker and Westenberg (2000) investigated the word order of Dutch sentences which are the equivalent of 'The man called the police because his wallet was stolen', or 'The man called the police because his wallet stolen was'. They found that the word order of target completions was influenced by the word order of the primes. As the concepts in these sentences are in the same order regardless of the actual word order, Hartsuiker and Westenberg argued that the effect could not be due to conceptual factors. Instead, the results were again consistent with the claim of a linearization process which computes word order. Again, they argued that this operated on a structure specified for functional relations and hierarchical relations but not word order. This process would add to the efficiency of the language production system as it allows for incrementality; a constituent which is available early on can be placed in the earliest possible part of the sentence, producing a fluent flow of language. Interestingly, Hartsuiker and Westenberg found similar effects for experiments in both the written and spoken modalities, supporting the hypothesis that the mechanisms underlying grammatical encoding in written production are at least similar if not the same as the mechanisms underlying spoken production.

Hartsuiker et al. (1999) and Hartsuiker and Westenberg (2000) argued for a multi-stage account of the formulation of constituent structure, composed of a dominance only level, and a linearized level. For example, in the case of a dative sentence, the system first selects whether it will produce a DO structure, or a structure involving a prepositional phrase (this could take the form of a PO or a shifted structure, equivalent to the medial dative in Dutch e.g. 'the child showed to the parent the painting').

Having selected a structure involving a prepositional phrase, the system will select either the PO or shifted construction during linearization. A contrasting, single stage account would propose that formulation of constituent structure would proceed in one step. So, the choice between the PO, shifted and DO syntactic forms would be made at one level. Pickering, Branigan and McLean (in press) argued that the results observed by Hartuisker et al. were consistent with both of these accounts. Using a written sentence completion task, Pickering et al. found that 'shifted' primes did not prime the production of PO target structures relative to an intransitive baseline prime. They argued that this was consistent with a single stage model, as PO, DO and shifted structures are represented at a single level. However, they argued that it was inconsistent with the multi-stage model proposed by Hartuisker et al. Because the multi-stage model argues that PO and shifted responses reflect the same representation at the first stage, and because shifted responses are very rarely produced by speakers, Pickering et al. argued that shifted prime responses should lead to a higher proportion of PO target responses than a baseline prime. However, this did not appear to be the case. Pickering et al. concluded that the pattern of results was consistent with the view that constituent structure is formulated in one stage.

Another interesting effect in the syntactic priming literature was found by Hartuisker and Kolk (1998) who examined priming in Broca's aphasics as well as normal subjects. Interestingly, the Broca's aphasics showed a priming effect, and when primed produced complex structures such as passives which they would not normally produce. These findings may have implications for the hypothesis that priming somehow aids fluency by allowing the subject to reuse structure rather than build syntactic structure for each utterance. Given that Broca's aphasics would normally find it very difficult to produce these structures, the results suggest that priming may indeed have an adaptive function, in that it reduces processing costs.

Potter and Lombardi (1998) investigated priming using a sentence recall technique. This research was prompted by Potter and Lombardi (1990) and Lombardi and Potter (1992). Potter and Lombardi (1990) observed that people are capable of recalling sentences with lengths of 14-20 words. Given that models of short-term memory suggest that humans can usually only hold around seven items in short term memory (Miller, 1956), short term memory in itself cannot be sufficient to account for our ability to recall

sentences. Potter and Lombardi (1990) examined this apparent discrepancy. They gave subjects a sentence to read, followed by a distractor task, and then asked the subject to recall the original sentence which they had read. If a 'lure' word was presented (which was a plausible replacement for one of the words in the sentence) as part of the secondary task, it was likely to intrude upon the recalled sentence. Subjects were likely to recall the original sentence with the lure word in place of the word it was a plausible replacement for. Potter and Lombardi (1990) concluded that speakers do not retain a reliable surface representation of a sentence that preserves word order and the words themselves. Instead, they argued that speakers recall sentences they have previously comprehended by regenerating them from scratch, and using recently activated lexical items. As under normal circumstances these would be the only plausible candidates for the message they were expressing this would result in almost verbatim recall; but as displayed by the data, this process could be disrupted when another recently activated item was a plausible candidate for the sentence.

Lombardi and Potter (1992) addressed the question of whether the surface syntax of a perceived sentence was represented in memory. Reusing the method of Potter and Lombardi (1990), they manipulated whether sentences could involve alternator or non-alternator verbs. For example, a subject might be given a DO sentence involving the word 'gave', which can appear with either the DO or PO form. The lure word would then be a non-alternating verb, for example 'donate', which can only appear in the PO form. They found that if subjects produced a non-alternating lure word which was inconsistent with the structure of the original sentence, they almost invariably spontaneously changed syntactic structure. In a variation, subjects were given alternator sentences to read, and were then presented with a non-alternator verb and asked if it could substitute for the verb in the original sentence. Subjects showed a tendency to claim that it could, and when recalling the sentence alter the structure if necessary, so that the sentence would be grammatically correct. Lombardi and Potter concluded that this supported the hypothesis that the surface form of the sentence was not explicitly represented in memory; but was instead generated using the usual grammatical encoding mechanisms, and with the verb determining the word order. However, this account did not explain why subjects usually recalled their sentences with the same structure as the originals, all things being equal. As alternator verbs allow either the PO or DO structure,

the hypothesis would suggest that one structure should be as likely to occur as the other. Lombardi and Potter suggested that recently activated syntactic structures were likely to be re-used.

Potter and Lombardi (1998) tested the hypothesis that syntactic priming was a factor contributing to verbatim recall. Prime sentences were presented and recalled by subjects, and then target sentences were presented and recalled. When the prime mismatched the target with an alternative structure, the alternative structure was frequently used by the subjects when recalling the target sentence. In subsequent sentences, the prime and target were both clauses within one sentence (e.g. 'The waitress handed a customer two glasses and then sent the manager her resignation'). Potter and Lombardi manipulated which of the clauses within the sentence was the prime and which was the target. Regardless of whether the prime sentence had been read and recalled, or just read before the target clause was recalled, there was a priming effect. Potter and Lombardi concluded that there are in fact three distinct mechanisms involved in verbatim memory. The first is the conceptual representation of the sentence's meaning, which can be expressed by regenerating the sentence using normal production mechanisms. The second is the activated trace of the lexical items of the perceived sentence. As these lexical items have been recently activated, the speaker is likely to reuse them. The third is the syntactic priming effect, which means that the subject is likely to reuse the syntactic structure of perceived sentence when they recall it. They also argued that this account was consistent with the relatively rapid loss of verbatim memory for a sentence, as the processes involved are subject to rapid decay.

The rate at which syntactic priming effects decay has been assessed in a number of studies (Branigan, Pickering & Cleland, 1999; Branigan, Pickering, McLean & Stewart, 2000; Bock & Griffin, 2000). Using the written sentence completion technique developed by Pickering and Branigan (1998), Branigan et al. (1999) found that the syntactic priming effect decayed rapidly. So, when even one sentence intervened between the prime and target sentences, the magnitude of the priming effect was drastically reduced, and it completely disappeared when there were four sentences intervening between prime and target.

Bock and Griffin (2000) investigated this issue using the spoken picture description method (Bock, 1986b), with sentences intervening between the production of a prime and the target picture

description. They found that priming effects persisted over as many as ten intervening sentences. This stand in contrast to the result of both Levelt and Kelter (1982), who found that syntactic repetition dissipated over one intervening sentence, and Branigan et al. (1999). Bock and Griffin suggested that syntactic priming may have an implicit learning element, given that speakers did not intend to memorise the form of a sentence, yet it seemed to have a long-lasting effect. They contrasted this with a transient memory account of syntactic repetition, arguing that such an account was not consistent with the persistence of the priming effect they found.

Branigan et al. (2000) used a spoken version of the sentence completion technique to investigate the rate of decay of priming in spoken production. They found that in this case, priming did not dissipate over an intervening item, or over a period of time equivalent to an intervening item. This was consistent with the finding of Bock and Griffin (2000) that priming (at least in spoken production) is not as short-lasting a phenomenon as the initial research suggested. Branigan et al. concluded that the reason that the original study found a very short effect of priming was the written nature of the task.

Fox Tree and Meijer (1999) used a technique where subjects read and tried to memorise a sentence. They then read a prime sentence as part of a distractor task, then recalled the original target sentence. Subjects presented with PO primes were likely to produce target sentences originally presented in the DO form with a PO structure. This effect occurred when the prime and target sentences were matched in complexity, and when they differed in complexity. For example, a target sentence such as 'The widow gave the university she had graduated from a million dollars that was bequeathed from her great aunt' was likely to be mis-remembered as a result of a PO prime, as was a target sentence such as 'The widow gave the university a million dollars'. Fox Tree and Meijer argued that their results supported a two-tiered system of syntax generation where major constituents were recalled first and then subroutines built the structures within these constituents. They also argued that, given that the complexity of the noun phrases did not affect the priming effect, the locus of the syntactic priming effect was the verb phrase.

Rather than examining the effect of primes on the structure of subsequently produced sentences, Smith and Wheeldon (2001) developed an online technique of measuring how the processing of certain syntactic structures could be eased by previous processing of the same structure. Using a method based on

Bock (1986b), subjects described moving objects, producing co-ordinate noun phrases for both the prime and target sentences. The movement of the objects which the speaker had to describe were manipulated to control the syntactic structure of their descriptions. Hence, a target description such as 'The spoon and the car move up' could be paired with either a syntactically unrelated description such as 'The eye moves up and the fish moves down', or a syntactically related prime such as 'The eye and the fish move apart'. Smith and Wheeldon found that the speech onset time for a target sentence preceded by a syntactically related prime was 50 milliseconds shorter than that for a target sentence preceded by a syntactically unrelated prime. In a series of experiments, they ruled out factors such as priming of visual perception or lemma availability as the source of the syntactic repetition, and concluded that the reduction in speech onset times between primed and unprimed trials reflected the fact that structural priming reduces the time dedicated to the generation of syntactic structure. This supported an 'effort reduction' theory of syntactic priming, previously suggested by Bock (1986b), that reusing syntactic structure has benefits for the speaker in that it reduces processing costs. In addition, these findings suggest a very short-term component to priming, contrasting with the longer term mechanisms suggested by, for example, Bock and Griffin (2000) and Hartsuiker and Kolk (1998).

Syntactic priming effects have been taken as evidence that conceptual and syntactic features have independent and additive effects (e.g. Bock, 1986b). However, Heydel and Murray (2000) argued that conceptual form is critically involved in priming effects. They found cross-linguistic priming effects in German and English; crucially, German topicalizations (e.g. equivalent to the dislocated actives studied by Prat-Sala & Branigan, 2000) behaved as German passives in priming English passives. Topicalizations and passives have the same conceptual form but different syntactic forms, so Heydel and Murray argue that there must be a conceptual element to priming. This is an interesting conclusion, although critics might argue that translation effects obscure the data. Certainly the role of conceptual factors in priming is still under debate; it may be that actives and passives are more prone to these effects than dative structures as a speaker's choice of an active or passive structure could affect the degree of focus on entities within a sentence.

Branigan, Pickering and Cleland (2000) looked at syntactic repetition in dialogue using a confederate priming technique. Pairs of speakers took it in turns to describe pictures to one another, and to match pictures to their partner's description. One of the speakers was in fact a confederate of the experimenter and therefore was scripted to produce either a PO or a DO description of a card on experimental trials. They found that the subject's subsequent card description was influenced by the structure of the preceding prime trial; in other words, the subjects showed a strong tendency to use the same structure as the utterance they had just heard. As the prime and target pictures did not contain the same entities and the message produced in both the PO and DO forms were essentially the same, they argued that the effect could not be attributed to lexical repetition or meaning-based coordination as in previous dialogue studies of repetition (e.g. Garrod & Anderson, 1987). Branigan et al. termed this a 'syntactic coordination' effect as it occurred between interlocutors and concluded that it was likely that the representations underlying syntactic structure were shared between comprehension and production, consistent with the model described by Levelt et al. (1999). In addition, they argued that their results were inconsistent with an account of priming which was based on residual activation of procedures associated with producing syntactic form (e.g. Bock & Loebell, 1990). As the procedures involved in comprehension and production are not the same, this account would not explain the presence of syntactic priming from comprehension to production. Instead, the results supported the model proposed by Pickering & Branigan (1998) where priming arose as a result of residual activation of syntactic information at the lemma level, in other words, lemma nodes, combinatorial nodes and the links between them.

The results of syntactic priming studies demonstrate that another factor influencing a speaker's choice of syntactic structure is the structure of the sentences he or she has processed previously. This effect has also proved to be a useful tool for investigating how syntactic information is represented and processed during language production. This thesis uses syntactic priming as a tool to further investigate these representations and processes.

1.6 Summary

This chapter reviewed the dominant models of language production (Levelt et al., 1999; Dell, 1986), and some of the empirical evidence which has been cited in support of them. Both of these models postulate that semantic, syntactic and word-form information is represented separately; however, there are a number of differences between them. Most importantly, the Levelt model postulates that activation is feedforward only, whereas the Dell model allows a degree of interactivity between the three levels of representation. There are a number of factors which can influence a speaker's choice of syntactic structure; one aspect of this is the relative accessibility of the elements within the sentence, which has been shown to influence word order in a number of studies. In addition, the previous processing of a given syntactic structure is likely to result in it being re-used in subsequent utterances. This 'syntactic priming' effect has proved to be informative about the nature of syntactic representations in language production.

1.7 Goals of the thesis

The main aim of this thesis is to investigate the processing and representation of syntactic information in language production, using the syntactic priming paradigm (e.g. Bock, 1986b; Pickering & Branigan, 1998). The thesis concentrates primarily on a view of language production based on lexical retrieval (e.g. Levelt et al., 1999), rather than an account where syntactic processes are envisioned as a set of 'procedures' or 'frames'. There are a number of reasons for this. The first is that models of language production based on lexical retrieval currently dominate this field of research (e.g. Levelt, 1989; Levelt et al., 1999; Dell, 1986) and a great proportion of production research is interpreted in terms of these models. As such, it seems most useful to base the thesis on this approach. In addition, models of lexical retrieval are very well defined in terms of the mechanisms and processes underlying them, whereas models based on the activation of procedures or rules less so. Another reason is that the syntactic priming literature seems most consistent with accounts where priming is due to activation of representations (e.g. Pickering & Branigan, 1998). For example, the finding that syntactic priming occurs between interlocutors (e.g. Branigan, Pickering & Cleland, 2000) strongly suggests that it is residual activation of representations



rather than procedures which gives rise to the priming effect, as representations can be shared between comprehension and production.

As one of the most clearly specified accounts of syntactic priming, the model advocated by Pickering and Branigan (1998) will be taken as a starting point for much of the discussion throughout the thesis. This model fits well within the framework of Levelt et al. (1999) and the thesis aims at least in part to assess this framework. This is not to say that other accounts of priming have not been suggested. For example, an implicit learning account of priming has been proposed (e.g. Bock & Griffin, 2000). However, as these accounts have not really been fleshed out, or really discussed in terms of how they fit into the wider picture of models of language production, their discussion will be more limited. In actual fact, some of the issues investigated (for example, whether syntactic processes and representations are shared between spoken and written production, and the degree to which semantics and phonology affect syntactic choice) result in broadly the same conclusions regardless of the specific model advocated.

The experiments in chapter 2 are designed in part as an introduction to the paradigm of syntactic priming, and in addition, examine the effect of time pressure on the magnitude of syntactic priming. This is motivated by previous observations that reusing syntactic structure may pose benefits for the speaker.

Chapter 3 presents 3 experiments which investigate how syntactic information is represented for written and spoken production. While models of language production are generally presented in terms of purely spoken production (e.g. Levelt, 1989), an effective model of production must be able to account for both spoken and written production. The issue of whether syntactic information is shared between writing and speaking is examined using a cross-modality priming paradigm where prime and target sentences can be produced in the spoken or the written modality. The results are discussed in terms of their implications for representing orthographic and phonological information within one model of production.

Chapter 4 presents experiments which address 2 issues with respect to syntactic representations. The first issue is whether syntactic representations are shared between comprehension and production. The second is how semantics and phonology interact with syntactic processes. In addition, these studies look at priming of noun phrase structure, leading to an expansion of the Pickering and Branigan (1998) account to include information for nouns as well as verbs.

In more general terms, the experiments in the thesis are designed to investigate the nature of syntactic representations; how syntax is accessed in different modalities, and how it interacts with the other stages of language production. As this thesis aims to assess models of lexical access such as that of Levelt et al. (1999), the Pickering and Branigan (1998) model will be focussed on , and the results discussed in terms of how consistent they are with this model, and the modifications which they might suggest.

Chapter 2

Time pressure and syntactic priming

2.0 Overview

This chapter investigates the influence of time pressure on the repetition of syntactic structure in language production. I will review research which suggests that the high degree of repetition in language may reduce processing costs for the speaker, thus aiding fluency. In addition, some research suggests that syntactic priming may be increased over very short latencies. This might suggest that speakers placed under time constraints would be more likely to show syntactic priming effects than speakers who were not. In Experiments 1 and 2, speakers were placed under varying degrees of time pressure while completing sentence fragments. The sentence fragments were designed so that the magnitude of within speaker syntactic priming could be assessed (based on Pickering & Branigan, 1998). In addition, the lengths of the speakers' utterances were analysed. The magnitude of priming was not reliably influenced by whether the speaker was under time pressure or not. This is consistent with previous findings that syntactic priming does not decay very rapidly in spoken production (Branigan, Pickering, Stewart & McLean, 2000; Bock & Griffin, 2000). However, speakers produced shorter utterances when they had less time to complete a sentence, suggesting that time pressure did influence formulation processes.

2.1 Introduction

A growing body of research demonstrates that language production is highly repetitive (e.g. Tannen, 1984, 1989; Aijmer, 1996; Miller & Weinert, 1998). Despite the almost limitless combinations of words which speakers are capable of producing, they tend to reuse formulaic expressions, and speakers who use alternative (although grammatically sound) word combinations are perceived as less native-like in their speech (Pawley & Syder, 1983). Based on a spoken corpus of around 130,000 words of Canadian English, Sorhus (1976) settled on a figure of one fixed expression per 5 words. Altenberg (1990) concluded that approximately 70% of words produced in the London-Lund corpus formed part of 'recurrent word combinations'. Even written language appears to be highly repetitive despite the fact,

stylistically, this might seem less desirable; 34% of word combinations in the 1,000,000 word Brown corpus of written US English were found to be recurrent (Kjellmer, 1987). The repetition of word combinations is such an intrinsic part of language production that the lexicalization of fixed sentence stems has been integrated into theories of language production (e.g. Pawley & Syder, 1983; Kuiper & Haggio, 1984; Bod, 1999). Despite the fact that earlier theories of language would argue against the possibility (e.g. Chomsky, 1959), the idea that memorization of chunks of language is an important part of language acquisition has become accepted in current research (e.g. Nattinger & DeCarrico, 1989). In short, repetition is an important aspect of language production.

It is generally assumed that the function of this repetition is to aid the speaker in producing fluent speech. Support for this view comes from observations that as the speech rate of auctioneers and sports commentators rises, so does the proportion of repetitious formulaic language in their utterances (Kuiper, 1996); although at slower rates their utterances resemble everyday speech, at quicker rates there is an abnormally high proportion of 'speech formulas'. For instance, Kuiper and Haggio (1984) noted that the incredibly rapid speech produced by New Zealand auctioneers consisted in the most part of chunks of speech which had little syntactic or lexical variation. Kuiper and Haggio argued that these chunks were lexicalized units in long-term memory that could be retrieved when needed, so freeing up short-term memory for the demanding task of speaking fluently and quickly while attending to the audience (cf. Kuiper & Austin, 1990). It is not clear whether the speakers' use of 'speech formulas' is prompted by their rapid speech rate; or whether the speaker's rapid speech rate is itself a result of the 'speech formulas'. However, what is clear is that rapid speech rates and repetition coincide.

It is possible that repetition in speech functions to aid the listener, but research has increasingly shown speakers' strategies to be egocentrically motivated. Smith (2000) argued that, given speakers' tendency to use preformulated grammatical material, they appear to try and 'minimise their own formulation costs and shift as much of the processing burden onto the listener as possible' (p. 440). This conclusion was based in part on the observation that speakers do not produce a grammatical structure which corresponds entirely to the underlying conceptual structure of the message. Instead, they provide sufficient information that the original intended message can be reconstructed by the listener. Ferreira and

Dell (2000) found that use of the disambiguating 'that' in sentences such as 'the coach knew that you missed the practice' (versus 'the coach knew you missed the practice') was sensitive to the availability of spoken material rather than the need of the speaker. Clark and Wasow (1998) argued that some repetition of words arose from strategies which were designed to benefit the timing and continuity of utterances; e.g. while repeating words at the start of a complex utterance may simply reflect a disfluency, it may also be a strategy on the part of the speaker to buy some time to organise their utterance without leaving a silence which would risk losing the attention of the audience. Bard, Anderson, Sotillo, Aylett, Doherty-Sneddon and Newlands (2000) found that the intelligibility of speakers' articulation decreased as a map task progressed whether or not they were addressing new partners. Speakers are of course capable of taking into consideration their addressees when speaking (e.g. Fussell & Krauss, 1989); however, the extent to which speakers design their utterance with their audience in mind may be deceptive. Horton and Keysar (1996) concluded that, while on first appearance speakers often appeared to be taking into account their audience, in fact audience design was not necessarily a part of routine utterance planning, particularly when speakers were placed under the kind of time pressure typical of everyday conversation (for a review, see Keysar, Barr & Horton, 1998).

As previously discussed, speakers tend to repeat syntactic form in a number of settings (e.g. Weiner & Labov, 1983; Levelt & Kelter, 1982; Bock, 1986; Hartsuiker et al., 1999; Pickering & Branigan, 1998; see Chapter 1 for a review). Early work speculated that reusing syntactic structure may mean that the speaker did not have to generate speech completely anew. Having found repetition of surface form, Levelt and Kelter (1982) suggested that, while there may be semantic and pragmatic reasons for repeating surface form, there may be a benefit of reusing the available representations rather than regenerating an utterance:

... it is likely that reusing previous discourse elements has the additional function of facilitating the fluency of the formulation process itself. It may require less effort to reuse available surface materials wherever possible than to generate speech every time anew from a semantic base (Levelt & Kelter, 1982, p. 105).

Similarly, Bock (1986) observed that while reusing syntactic structure may limit the flexibility of language, 'reusing procedures already activated may ease the demands of message formulation and actually contribute to fluency' (p. 379-380). The finding of Smith and Wheeldon (2001) that speech onset times were reduced on syntactically primed trials confirmed this 'effort reduction' theory. Smith and Wheeldon concluded that the results were consistent with the view that speakers are more concerned with reducing their own processing costs than easing the comprehension of a listener. In addition, these results suggest that there may be a very short-term component to priming.

The data from studies of the rate of decay of syntactic priming are also relevant in view of this issue. Levelt and Kelter (1982) found that repetition of surface form dissipated rapidly, with one intervening utterance being sufficient to eliminate the repetition effect. As reviewed previously, Branigan et al. (1999) also found that syntactic priming effects appeared to be short-lived at least in written production. It might be argued that subjects under time pressure will show a greater tendency to repeat syntactic structure, as they will be likely to produce their utterances more rapidly, and therefore the activation of representations corresponding to a primed structure may be greater than the case where they have more time to formulate their utterance. However, others have found that syntactic priming effects persist over a number of trials (Branigan, Pickering, Stewart & McLean, 2000; Bock & Griffin, 2000).

There is some evidence that repetition increases with speech rate (Kuiper, 1996). In addition, primed sentences have a shorter speech onset latency than unprimed sentences (Smith & Wheeldon, 2001). Taken together, these results suggest that speakers might exhibit more syntactic priming when placed under time pressure than in a case where they have a relatively long time to formulate their utterance.

2.1.2 Sentence completion technique

Experiments 1 and 2 involved a spoken sentence completion technique based on Branigan et al. (2000). Participants read aloud and completed sentence fragments which were presented on a computer screen. The fragments could be manipulated so that they were more or less likely to produce a sentence with a PO or DO structure. For example, a prime sentence fragment such as 'The student loans the money'

is likely to result in a PO completion (e.g. 'The student loans the money to her sister'). Alternatively, a prime sentence fragment such as 'The student loans the friend' is likely to result in a DO completion (e.g. 'The student loans the friend a text book'). This manipulation is pragmatic in that it is based on making the post-verbal noun phrase either a good patient or a good beneficiary of an action. The sentence fragment contains the same syntactic structure in both cases (i.e. a noun phrase followed by a verb then another noun phrase). A target sentence fragment such as 'The teenager loans' is compatible with a PO completion (e.g. 'The teenager loans the bike to his friend'), a DO completion (e.g. 'The teenager loans his friend the bike') or an alternative (Other) completion (e.g. 'The teenager loans computer games out'). Using the sentence completion technique, it is possible to assess what proportion of target fragments are preceded by prime fragments of the same structure. In the following experiments, the sentence fragments were presented on a computer screen using PsyScope software (Cohen, MacWhinney, Flatts & Provost, 1993), and the participants read the fragments out loud, providing a grammatical completion before the sentence fragment disappeared and a beep sounded. In order to investigate the effects of time pressure, the sentence fragment could either be presented for a relatively short time (the 'Fast' condition), or for a relatively long time (the 'Slow' condition).

There are a few ways in which the participants might react to being under time pressure in the fragment completion task. A target sentence fragment such as 'The teenager loans' can be completed as a PO, DO or Other construction. PO or DO completions, while structurally different, have broadly similar interpretations (e.g. 'The teenager loans the book to his brother' vs. 'The teenager loans his brother the book'). However it may be that there are differences in formulation costs for the two structures. A PO sentence is slightly longer than a DO version of the same sentence, so it may be that speakers would rather produce a DO structure than a PO structure when under time pressure. Alternatively, if there are differences in the relative processing costs for PO and DO constructions, then this may result in a preference for one structure over the other in time pressure conditions. The Other structure can result in the shortest utterance, as speakers are able to provide completions with as few as one or two words (e.g. 'The teenager loans out CDs', 'The patient shows off'). These are grammatical sentences involving a minimum completion length. It may be that participants choose to produce Other structures more

frequently in the Fast condition as they allow the speaker to produce a very short utterance. This might imply that the cost of generating a new structure would be outweighed by the benefit of finishing the sentence more quickly. Alternatively, as this effect might arise at the conceptual level rather than the syntactic level, a decision to produce a shorter utterance may arise without any consideration for subsequent processing costs, such as those influenced by reusing syntactic structure.

Participants might display more syntactic priming when placed under time pressure. Syntactic priming is at its strongest the less time there is between prime and target, an effect which has been attributed to rapid decay of syntactic representations (Levelt & Kelter, 1982; Branigan et al., 1999). If participants produce utterances quicker in the Fast condition, we might therefore expect an increase in priming. Similar arguments have been made in other areas; for example, Vitkovitch and Humphreys (1991) found that subjects tended to produce perseverative naming errors when placed under time pressure in a picture naming task; producing the names of semantically related objects which they had previously named in the experiment. This was attributed to residual activation of mappings of semantic representations of pictures onto their names. The fact that the speakers have less time to formulate an utterance may minimise the influence of conceptual factors on their utterances, and hence increase the influence of automatic processes. This might result in a greater magnitude of syntactic priming.

Given that reusing syntactic structure reduces formulation costs, and results in a quicker speech onset (Smith & Wheeldon, 2001), an increase in the magnitude of priming might arise as speakers try and produce the most efficient response possible in the Fast condition, consistent with the 'effort reduction' theory of syntactic repetition. Speakers under time pressure tend to try and reduce their processing costs as far as possible and it is clear that reusing syntactic structure is an effective way of doing this.

In the following experiments the speed of both the prime and target sentences was manipulated. While the crucial point of interest was whether the magnitude of priming was increased when the target was presented in the Fast condition compared to the Slow condition, the effect of manipulating the speed of the prime was considered as well.

2.2 Experiment One

2.2.1 Method

2.2.1.1 Participants

Twenty-four students from the University of Glasgow community were paid to participate.

2.2.1.2 Items

Forty-eight experimental items were constructed, each consisting of two sentence fragments: e.g.

- 1a. The student loans the money
- 1b. The student loans the friend
- 2. The teenager loans

The first fragment (1a-1b) was the prime, and the second fragment (2) was the target. The prime and target fragments each contained a dative verb that could appear in both a PO and a DO construction. Prime fragments also contained a post-verbal noun phrase designed to elicit either a PO or a DO completion, so in this case, (1a) is designed to elicit a PO completion, and (1b) is designed to elicit a DO completion. The prime and target fragments employed six verbs (*gives, hands, loans, shows, lends and sends*), and the prime and target fragment always contained the same verb. In previous research, these verbs have led to a high proportion of PO and DO responses, and repeating the verb between prime and target has led to increased priming effects (e.g. Pickering & Branigan, 1998; Branigan, Pickering & Cleland, 2000). The sentence fragments did not contain any adjectives or adverbs so that they were all of a comparable length. This was because the subjects would be completing some of the fragments under a degree of time pressure and longer fragments may have resulted in subjects failing to complete items in the available time.

Each prime and target fragment could appear in a Fast or Slow form. The Fast condition corresponded to the case where the fragment was presented for a total of 3000ms, the Slow when it was presented for 6000ms. These presentation times were chosen following informal pilot versions of the

experiment which manipulated the length of time the fragment was presented for. During the pilot sessions, participants reported that 3000ms was the shortest time they could viably produce a completion, while 6000ms left them enough time to comfortably finish a sentence without feeling rushed, yet also without having to wait a long time for the next trial. The presentation time of both prime and target sentences were manipulated. The speed of the target was of the most immediate interest, as the target provided a measure of how likely speakers were to reuse syntactic structure under time pressure. However, the presentation time of the prime was also manipulated. This was in part because, had the prime been presented for the same length of time on each experimental trial, the experimental items may have been more obvious. In addition, it was possible (although unlikely given Branigan, Pickering, Stewart & McLean, 2000; Bock & Griffin, 2000) that decay would result in reduced priming in targets following a prime which was presented for a long time versus targets following primes presented for only a brief time. This could occur if there was a larger gap before the next trial following a Slow prime. Manipulating the presentation time of the prime fragment allowed any effect due to this to be accounted for. Hence, there were eight conditions:

Fast PO-inducing Prime x Fast Target
 Fast DO-inducing Prime x Fast Target
 Slow PO-inducing Prime x Fast Target
 Slow DO-inducing Prime x Fast Target
 Fast PO-inducing Prime x Slow Target
 Fast DO-inducing Prime x Slow Target
 Slow PO-inducing Prime x Slow Target
 Slow DO-inducing Prime x Slow Target

Eight lists of items were constructed (see Appendix), such that each list contained six items in each condition, and one version of each item. Each list also included 192 filler fragments, consisting of 84 noun phrase fragments, 53 noun phrase plus verb fragments, and 55 noun phrase plus verb plus another noun phrase fragments. No ditransitive verbs were used in the filler fragments, so that the subjects' completions on the filler trials would be unlikely to influence their completions on the experimental trials.

The fillers were allocated to the Fast or Slow condition with half of them appearing in each. The lists were individually randomised, with the constraint that at least three fillers intervened between each item.

The randomised lists were then entered into a PsyScope program (Cohen, MacWhinney, Flatts & Provost, 1993), which was designed to display each sentence in turn, and to provide a cue depending on whether the sentence fragment was to appear in the Fast or Slow condition. Fragments in the Fast condition were presented for 3000ms, and fragments in the Slow condition for 6000ms.

2.2.1.3 Procedure

Participants were seated in front of a computer in a quiet booth and given a set of written instructions (see Appendix). In a set of written instructions, they were told that the experiment was interested in what kinds of sentence people produce and that their task was to complete the sentences as quickly as possible, with the first grammatical completion that came to mind. They were also told that they would either have a very short time to produce their sentence (3000ms), or a relatively long time (6000ms), and that they would be given a prompt before each sentence fragment appeared to warn them how long they would have for that sentence.

On each trial, a prompt appeared for 2000ms indicating whether the participant would have a short or long time to complete the subsequent sentence fragment. If the sentence was going to be presented for a short time, the following prompt would appear:

-

If the sentence would be presented for a longer time, the following prompt would appear:

These prompts were presented in blue. Presenting the prompts in a different colour to the text distinguished them from the rest of the experiment, and it was important that participants paid attention and knew in which condition each sentence would be presented. Next, a fixation point (a black *) was presented for 500ms at the point where the sentence would begin, to ensure the subject was attending to the sentence when it appeared. Finally, the sentence was presented. After the sentence had been on screen for its allocated time, a beep sounded and the screen would clear for the next trial to begin. For the benefit

of the participants, four short rest breaks were inserted into each list, as the experiment lasted around 50 minutes. The rest breaks never occurred between a prime and a target sentence. Responses were tape recorded. A practice session of five sentences preceded the experiment proper during which participants could ask the experimenter questions about the procedure.

2.2.1.4 Scoring

The participants' responses to the experimental items were transcribed from the tape recordings and scored as PO, DO or Other. Prime responses were scored as POs if the completion contained a beneficiary noun phrase which was the object of the preposition 'to'. Prime responses were scored as DOs if the completion contained a patient (or theme) noun phrase. To be scored as either a PO or a DO response, the verb provided in the fragment could not form part of a phrasal verb (e.g. 'the banker hands the money over to the customer'), as this was not considered a PO construction. All responses which were not scored as a PO or DO were scored as Other. This included the case where subjects had failed to complete the sentence fragment before the beep sounded.

Target responses were scored as POs if the verb in the fragment was immediately followed by a noun phrase which acted as the patient or theme and then by a prepositional phrase beginning with 'to' which acted as the beneficiary. Target responses were scored as DOs if the verb was immediately followed by a noun phrase which acted as a beneficiary and then by a noun phrase which acted as the patient. To be scored in either category, a completion had to have a grammatical alternative in the alternative category, when the order of the patient and beneficiary was reversed, for example a sentence such as 'The woman sends the donation home' cannot be reversed to 'The woman sends home to the donation'. If the structure did not have a grammatical alternative in the other category, then the subject could not be considered to have chosen one structure over its alternative, and therefore these completions were excluded from the analysis. Again, the verb provided in the fragment could not form part of a phrasal verb (e.g. 'The secretary hands the memo over to the manager'). All target responses not scored as PO or DO were scored as Other. These are the same criteria as were used in Pickering and Branigan (1998).

2.2.1.5 Design and data analysis

Every participant completed 48 target fragments, six in each of the eight priming conditions defined by the two levels of the Prime Completion factor (PO vs. DO), the two levels of the Prime presentation time factor (Fast vs. Slow), and the two levels of the Target presentation time factor (Fast vs. Slow). Every experimental item was presented to all twenty-four participants, with three participants seeing any one version of an item.

The results were first analysed for Other responses, to determine whether the combined proportion of PO and DO target responses was comparable across priming conditions. Thus, the proportions of Other responses following Fast PO prime completions with a Fast target presentation time, Fast PO prime completions with a Slow target presentation and so on through all eight conditions were compared. The relevant proportions were calculated by dividing the number of Other target completions following Fast prime Fast target PO prime completions by the total number of Fast prime Fast target PO prime completions (i.e., Fast prime Fast target PO prime completions followed by Other, PO and DO target completions), and so on for the eight conditions. These proportions were calculated for each participant and for each item. Analyses of variance were performed on these data, with separate analyses treating participants (F1) and items (F2) as random effects. The analyses were within-participants and within-items.

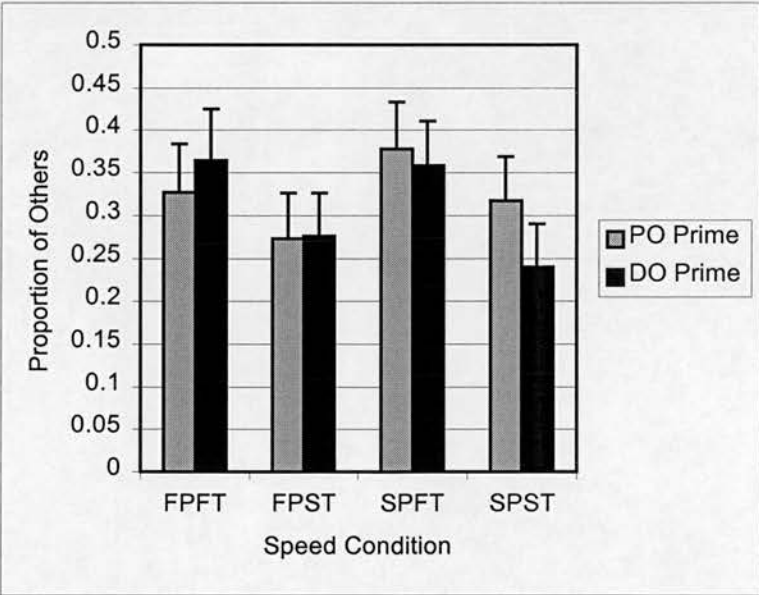
A measure was then computed which was designed to determine the relative proportions of PO and DO target responses in each of the priming conditions. This measure (the PO target ratio) was the proportion of PO target responses in a priming condition divided by the sum of the proportion of PO target responses and the proportion of DO target responses in that priming condition. This measure is employed because it allows the comparison of priming between conditions in cases when the proportions of Other responses are not equivalent. Because some responses were classed as Others, this calculation occasionally resulted in a missing value. So, if the speaker had produced no PO or DO completions in one condition, this would result in the nominator of the PO target ratio being 0, resulting in a missing value. In the event of this, the missing value was replaced with the overall mean of the PO target ratios across all

conditions. This measure has been used in previous research (e.g. Branigan, Pickering, Stewart & McLean, 2000).

2.2.2 Results

For reported statistics, values are given to two significant figures. All graphs represent the data for the subjects analysis, and error bars represent standard error by subjects.

Participants produced a PO or DO completion for the prime target fragment on 90% of trials; of these, 24% were Fast PO prime responses, 25% were Slow PO prime responses, 25% were Fast DO responses and 26% were Slow DO responses. ANOVAs on the proportion of Others revealed that there was a significant effect of Target Speed on the proportion of Others produced, although marginal by subjects, ($F(1,23)=3.40$, $p=.078$, $MSe=.091$; $F(2,47)=25.45$, $p<.001$, $MSe=.048$). The proportion of Others produced in the Fast Target Speed condition was higher than in the Slow Target speed condition (0.36 vs. 0.28). There were no other significant effects on the proportion of Others produced. For the proportions of Others produced across the experimental conditions see Fig. 3.



Note: FPFT: Fast prime, Fast target; FPST: Fast prime, Slow target; SPFT: Slow prime, Fast target; SPST: Slow prime, Slow target

Fig. 3. Proportions of Others produced in Expt. 1.

ANOVAs on the PO target ratio revealed an effect of Prime Completion ($F(1,23)=31.32$, $p<.001$, $MSe=.14$; $F(1,47)=89.21$, $p<.001$, $MSe=.073$). There was an overall priming effect of 30% (i.e. excluding Others, 30% more target completions were of the same structure as the prime completion than were of the alternative structure). The magnitude of priming was significantly increased when the target was in the fast condition, by subjects only ($F(1,23)=4.26$, $p=.05$, $MSe=.036$; $F(1,47)=.49$, $p=.49$, $MSe=.11$). When the target was presented in the fast condition, the magnitude of priming was 36%, and when the target was presented in the slow condition the magnitude was 24%. No other interactions were significant. See Fig. 4 for a summary of the PO Target Ratios produced across all conditions.

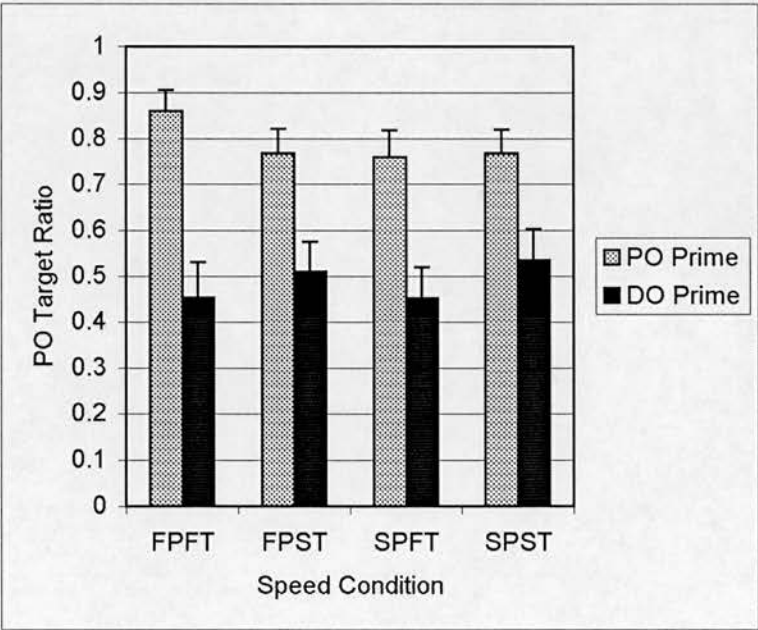


Fig. 4. PO Target Ratios for Expt. 1.

In addition, the target completion lengths were analysed (see Fig. 5 for a summary). The completion length of each target fragment was included in the analysis, except for the case when the subject had failed to finish the sentence before the beep at the end of the trial; in this case, the item was excluded from the analysis. 2x3 ANOVAs revealed that there was a significant effect of the Speed condition on the length of the target completion ($F(1,23)=4.67$, $p<.05$, $MSe=1.35$; $F(1,47)=21.02$,

$p<.001$, $MSe=.99$). When the target was presented in the Fast condition, the mean length of completion was 4.5 words; in the Slow condition, the mean length of the target completion was 5.0 words. There was also a main effect of structure ($F(2,22)=29.36$, $p<.001$, $MSe=1.33$; $F(2,46)=108.40$, $p<.001$, $MSe=.87$). When the target was a PO structure, the mean completion length was 5.4 words, when it was a DO structure, it was 4.7 words and with an Other structure it was 4.1 words. Planned comparisons revealed that Other responses were significantly shorter than PO and DO completions for the Fast condition ($F(1,23)=29.52$, $p<.001$, $MSe=1.17$; $F(1,47)=123.95$, $p<.001$, $MSe=.76$) and had a tendency to be shorter in the Slow condition ($F(1,23)=2.54$, $p=.12$, $MSe=1.34$; $F(1,47)=25.4$, $p<.001$, $MSe=1.35$). There was also an interaction of Speed by Structure ($F(1,22)=5.72$, $p<.01$, $Mse=1.3$; $F(2,46)=5.79$, $p<.01$, $MSe=.76$).

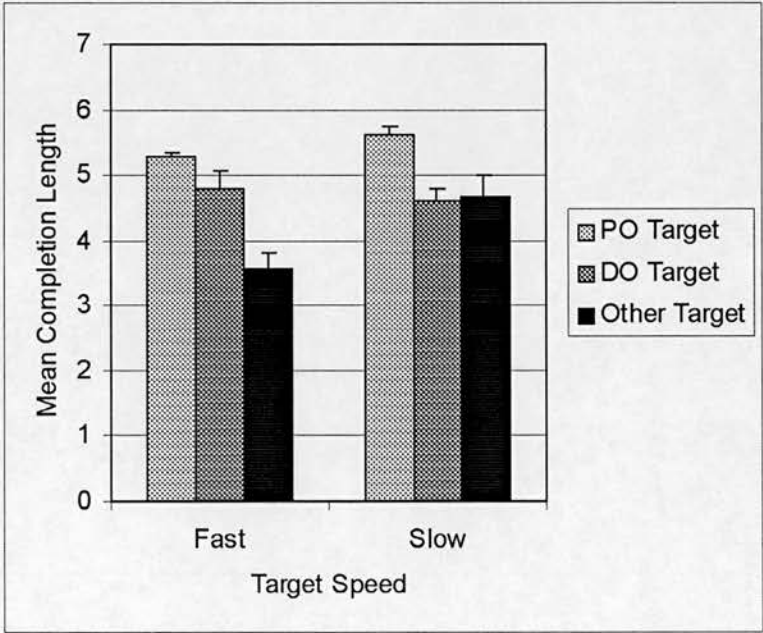


Fig. 5 Sentence Completion Lengths for Expt. 1.

2.2.3 Discussion

Expt. 1 demonstrated that subjects were significantly more likely to produce a target utterance with the same structure as the prime utterance than with the alternative ditransitive structure; they produced 30% more utterances of the same construction as the prime than of the alternative. This is

consistent with previous findings of syntactic priming using a spoken sentence completion technique (Branigan et al., 2000). There was a tendency for the magnitude of priming to be greater when subjects were under time pressure to produce the target sentence (36% priming in the Fast condition versus 24% in the Slow condition). However, this tendency was not significant by items analysis. This increase provides some tentative evidence that speakers are more likely to reuse syntactic structure when under time pressure. This could reflect a very short-term reduction in the effect of syntactic priming, consistent with a rapid decay of syntactic representations (e.g. Branigan et al., 1999) and with a short-term element to the priming effect (e.g. Smith & Wheeldon, 2001). This is consistent with the idea that repetition of syntax has an adaptive function (e.g. Levelt & Kelter, 1982; Bock, 1986; Smith & Wheeldon, 2001), in that reusing structure appears to reduce processing costs for the speaker. Research on the repetition of other aspects of language such as lexical repetition and the use of formulaic expressions (e.g. Kuiper, 1996) has shown that repetition increases as speakers are placed under increasing time pressure and need to produce utterances at a quicker rate. As a by-product of this, speakers may appear to produce more repetition of syntactic structure; however, the finding that syntactic priming is enhanced under time pressure would suggest that a similar effect occurs at the level of syntactic structure. The fact that the effect was non-significant by items suggests an item specific effect. It is difficult to say what this might reflect. It could be a result of the relative difficulties of completing different items; while all items were fairly simple, it may be that some (e.g. 'the lecturer gives the book') were easier to provide a quick completion for than others (e.g. 'The diplomat hands the documents'). In any case it is not clear, at least on the basis of these results, what effect time pressure has on the magnitude of priming.

The results suggested that speakers were choosing to reduce the lengths of their utterances when placed under time pressure, with completion lengths significantly shorter across the Fast condition. Participants produced more Other completions when placed under time pressure (36% of target completions were Others in the Fast condition versus 28% in the Slow condition). An analysis of the completion lengths revealed that Other completions were significantly shorter than PO and DO completions; in particular, Other completions in the Fast condition were the shortest utterances produced. As items were excluded from the analysis when subjects failed to complete their utterance before the end

of the trial, this effect cannot just be due to the speakers running out of time in the Fast condition. Instead, it suggests that producing shorter utterances was a strategy on the part of the speaker when placed under time pressure. While reusing syntax may save time during formulation, speakers produced shorter utterances under time pressure when they had control the content of their sentence. This issue will be returned to in the General Discussion.

Expt. 2 was based on Expt. 1, with the variation that the verb was different between the prime and target sentences. There were a couple of reasons for running this experiment. The pattern of experiments in Expt. 1 was inconclusive on the issue of the effect of time pressure on priming. A replication of the results which was significant by items would strengthen the conclusions. By keeping the verb different between prime and target, Expt. 2 allowed a comparison with Expt. 1 over the issue of whether verb repetition enhances syntactic priming effects. As reviewed earlier, the finding that syntactic priming effects are increased when the verb remains the same between prime and target versus the case where it is different has led to modifications of models of the lemma stratum (e.g. Pickering & Branigan, 1998).

2.3 Experiment Two

2.3.1 Method

2.3.1.1 Participants

Twenty-four participants from the University of Glasgow community were paid to participate.

2.3.1.2 Items

The same set of items was used as in Expt.1. The targets remained the same, and the prime sentences were rotated so that the prime and target sentences contained different verbs: e.g.

1a. The banker hands the money

- 1b. The banker hands the customer
- 2. The teenager loans

The same set of fillers was used as in Expt. 1.

2.3.1.3 Procedure, Scoring, Design and Data Analysis

See Expt. 1.

2.3.2 Results

Participants produced a PO or DO completion to the prime fragments on 93% of trials; of these, 25% were Fast PO primes, 25% Slow PO primes, 25% Fast DO primes and 25% Slow DO primes. ANOVAs on the proportion of Others revealed that there was a significant effect of Target Speed on the proportion of Others produced ($F(1,23)=5.04, p<.05, MSe=.062$; $F(1,47)=7.93, p<.01, MSe=.054$). The proportion of Others produced in the Fast condition was 0.35, as opposed to 0.27 in the Slow condition. (see Fig. 6). There was a tendency for more Others to be produced following PO primes than DO primes; however, this was non-significant ($F(1,23)=4.0, p=.06, MSe=.036$; $F(1,47)=1.71, p=.20, MSe=.066$). The proportion of Others following a PO prime was 0.33 and following a DO prime 0.28.

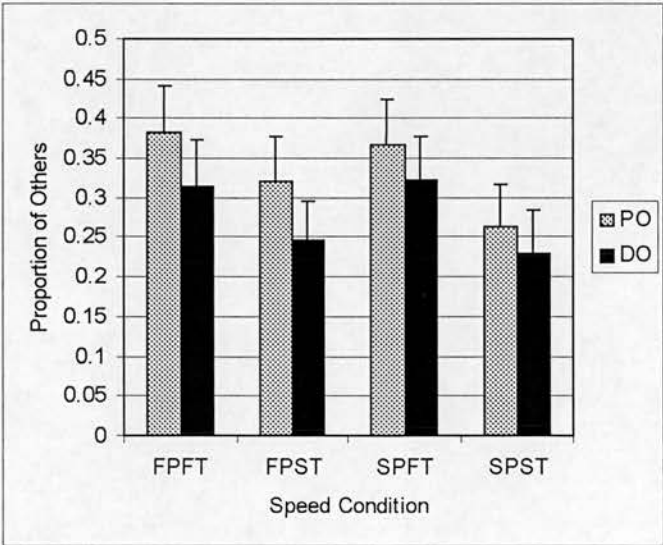


Fig. 6. Proportion of Others produced in Expt. 2.

ANOVAs on the PO Target Ratio revealed an effect of Prime Completion ($F(1,23)=17.76$, $p<.001$, $MSe=.122$; $F(1,47)=35.97$, $p<.001$, $MSe=.089$). There was an overall priming effect of 21% (i.e. 21% more target completions were of the same structure as the prime completion than were of the alternative structure). The speed manipulations had no significant effect on priming. Again, the magnitude of priming was larger when the target was presented in the fast condition (25%) as opposed to the case where it was presented in the slow condition (17%); however, this interaction was non-significant ($F(1,23)=1.62$, $p=.22$, $MSe=.052$; $F(1,47)=.08$, $p=.78$, $MSe=.11$). Fig. 7 shows the PO Target Ratios across all conditions in Expt. 2.

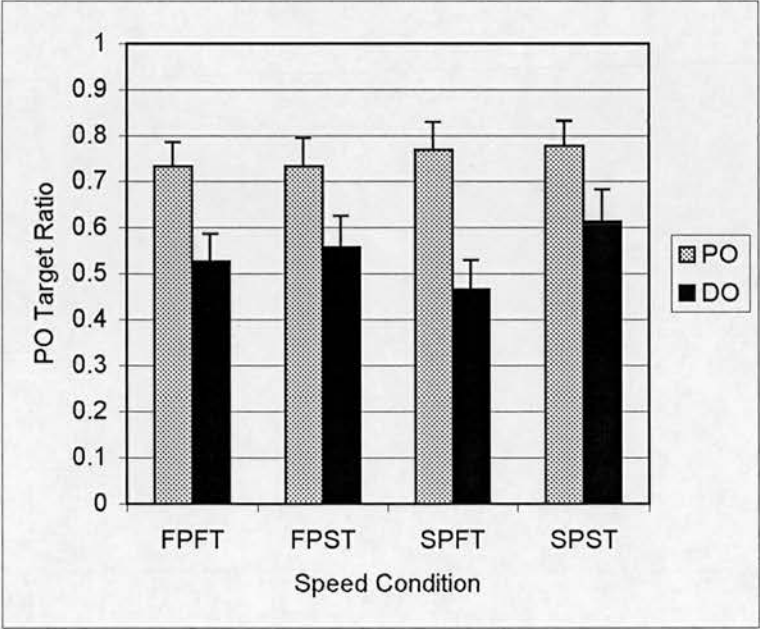


Fig 7. PO Target Ratios for Expt. 2.

In addition, the length of the target completions was analysed, excluding cases where an Other had been produced because the subject had not had time to complete a full sentence (see Fig 8 for summary). 2x3 ANOVAs revealed that there was a significant effect of Speed condition on the length of the target utterance produced ($F(1,23)=8.16$, $p<.01$, $MSe=1.04$; $F(1,47)=14.03$, $p<.001$, $MSe=1.11$). When the target was presented in the Fast condition, the mean completion length was 4.6 words; in the

Slow condition, the mean completion length was 5.0 words. There was also a main effect of Structure ($F(2,22)=34.96, p<.001, MSe=.66; F(2,46)=47.14, p<.001, MSe=1.36$). When the target was a PO structure, the mean completion length was 5.5 words, when it was a DO structure it was 4.7 words and when it was an Other structure it was 4.2 words. Planned comparisons revealed that the Other completions were significantly shorter than the PO and DO completions in both the Fast condition ($F(1,23)=14.83, p<.001, MSe=.71; F(1,47)=22.98, p<.001, MSe=2.14$) and the Slow condition ($F(1,23)=15.61, p<.001, MSe=.80; F(1,47)=28.29, p<.001, MSe=1.53$). There were no other significant interactions.

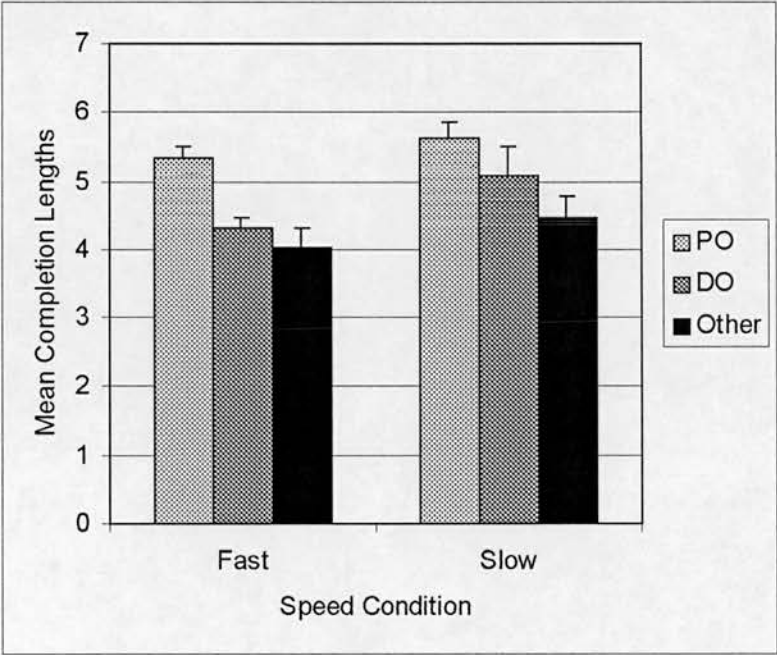


Fig 8. Target Completion Lengths for Exp. 2.

2.3.3 Discussion

Again, Expt. 2 demonstrated that subjects were significantly more likely to produce a target utterance with the same structure as the prime utterance than with the alternative structure; they produced 21% more utterances of the same construction as the prime than of the alternative. The magnitude of priming was 25% when subjects were placed under more time pressure to produce the target sentence, and 17% when they were under less pressure; however, this difference was non-significant. While Expt. 1

appeared to show a tendency in this direction, Expt. 2 did not show that speakers are reliably more likely to reuse syntactic structure under time pressure conditions. This is consistent with the finding that syntactic priming does not decay rapidly in spoken production (Branigan, Pickering, Stewart & McLean, 2000; Bock & Griffin, 2000), and suggests that the kind of immediate, short-term effect observed by Smith and Wheeldon is not sufficient to affect the structure of spoken production, at least when content is not specified for the speaker.

As with Expt. 1, there was evidence that speakers were choosing to reduce the lengths of their utterances when placed under time pressure. Completion lengths were significantly shorter across all prime conditions in the Fast condition than they were in the Slow condition. Participants produced more Other completions when placed under time pressure (35% target completions were Others in the Fast condition, and 27% target completions were Others in the Slow condition), and the Other completions were significantly shorter than the PO or DO completions. These observations converge to suggest that the speakers were reducing the length of their utterances when placed under time pressure, which resulted in the increase in Other target completions in the Fast condition.

Again, it appears that subjects were not more likely to reuse syntactic structure when under time pressure than when not. Instead, they chose to produce shorter sentences when they were under time pressure to produce an utterance.

2.4 Combined Analysis of Expt. 1 and Expt. 2

A cross experiment comparison was carried out, in part to investigate whether priming was significantly enhanced by repetition of the verb (cf. Pickering & Branigan, 1998), and in part to determine whether the tendency towards enhanced syntactic priming under time pressure was significant across the 2 experiments. As Expt. 1 and Expt. 2 used the same experimental target items, the analysis was between subjects and within items. As for the analyses for Expt. 1 and Expt. 2, an analysis of the proportions of Other responses revealed that significantly more Others were produced in the Fast (0.35) than the Slow (0.27) conditions ($F(1,46)=8.13$, $p<.01$, $MSe=.077$; $F(1,47)=24.80$, $p<.001$, $MSe=.063$). When the experiments were considered together, there was a significant effect of target speed on the magnitude of

priming by subjects, but not by items ($F(1,46)=5.3$, $p<.05$, $MSe=.23$; $F(1,47)=.49$, $p=.49$, $MSe=.052$), with an overall 31% magnitude of priming in the Fast target condition, and 21% in the Slow target condition. A comparison of the magnitude of priming in the two experiments revealed that priming was significantly stronger in Expt. 1 when the verb was repeated between prime and target but only by items ($F(1,46)=1.45$, $p=.24$, $MSe=.13$; $F(1,47)=6.14$, $p<.05$, $MSe=.048$). This finding is consistent with previous findings that priming is enhanced when the verb is repeated between prime and target (e.g. Pickering & Branigan, 1998; Branigan, Pickering & Cleland, 2000). There were no other significant effects.

2.5 General discussion

Experiments One and Two were conducted with the aim of investigating whether speakers had an increased tendency to reuse syntactic structure when they had limited time to produce a target sentence. Overall, there was a significant priming effect; in Expt. 1, speakers produced 30% more target utterances with the same construction as the prime utterance than with the alternative structure, and in Expt. 2 there was a 21% priming effect. This is consistent with the well-established finding that speakers have a tendency to reuse syntactic structure in consecutive utterances (e.g. Bock, 1986; Hartsuiker & Kolk, 1998; Pickering & Branigan, 1998). The priming effect tended to be diminished when the verb differed between prime and target fragments compared to when it remained the same between prime and target fragments; however this effect was only significant by items. This replicates previous findings that priming of ditransitive structures is enhanced by repetition of the verb (e.g. Pickering & Branigan, 1998; Branigan, Pickering & Cleland, 2000).

In terms of the time-course of the activation of syntactic information, the results are consistent with the findings of Branigan, Pickering, Stewart & McLean, (2000) and Bock and Griffin (2000) that priming effects do not decay rapidly. If there are any extremely short term effects of the activation of syntactic structure (Smith & Wheeldon, 2001), these are either too weak to manifest themselves in an increase in syntactic priming using this method, or they dissipate so rapidly that they do not affect

subsequent utterances. It is possible that while syntactic repetition can influence the speed of speech onset, these effects do not influence choice of syntactic form.

Levelt and Kelter (1982) suggested that reusing syntactic structure might reduce processing costs for the speaker, and Smith and Wheeldon (2001) provided experimental support for this 'effort reduction' hypothesis when they demonstrated that primed sentences have a shorter speech onset time than unprimed sentences. There is already evidence that speakers will reuse set phrases when they are producing rapid speech (Kuiper, 1996). This led to the prediction that speakers might be more inclined to produce the same syntactic structure in the target as in the prime when they were under time pressure. There was a tendency for the magnitude of priming to increase when the participants were given a brief time to provide a sentence completion in both experiments; however this was only significant by subjects in Expt. 1. This lends some support to the 'effort reduction' theory, although the results were not reliable enough to conclude that speakers will consistently reuse syntactic structure in a time pressure situation.

The hypothesis that early, residual activation is consistent with the 'effort reduction' view is supported by Smith and Wheeldon's results. However, an implicit learning mechanism could also be consistent with the 'effort reduction' hypothesis, such as that suggested by Bock and Griffin (2000). According to this view, the reuse of previous structures would stem from a longer term implicit learning mechanism. This could indeed result in speakers producing sentences more fluently; however, the effects observed by Smith and Wheeldon were very short term and therefore supportive of a residual activation account rather than an implicit learning account. It might be argued that, as time pressure did not affect the magnitude of syntactic priming in these experiments, the results support an implicit learning account. The problem with this argument is that it is based on a null result, and in fact the marginal significance by subjects analysis in Expt. 1 is a particular difficulty. In other words, the results are not conclusive enough to rule out a residual activation account in favour of an implicit learning account, especially given that accounts of syntactic priming based on implicit learning mechanisms are not yet well defined (cf. Branigan et al., 1999 for short-lived priming effects).

It is worth considering that the possibility that the Fast and Slow trials were mixed throughout the experiment may have led to an overall increase in priming through the experiment rather than solely on

the Fast trials. The fact that the participants were constantly aware of the time in which they had to complete their utterances might have had a wider effect on the magnitude of priming, not dissimilar to the effect of long term priming (Hartsuiker & Kolk, 1998). On the basis of these results alone, it is difficult to discount this suggestion; however this would have seen an increase in priming across all conditions and so should not affect the final conclusions. Another possibility is that, while speakers were given cues to alert them to the presentation time of the next sentence fragments and were told to pay attention to these cues, they did not in fact do this; possibly, over the course of the experiment, they began to treat every trial by default as a Fast trial. This seems unlikely, given that the pattern for results is different for the Fast and Slow target completions. Subjects produced more Others in the Fast condition, and their utterances were shorter in the Fast condition. This suggests that (at least to some extent) they were taking into account the presentation times when they formulated their utterances.

Participants showed a significant tendency to produce more Other structure target responses in the Fast condition. Other responses were counted as any response which did not match the PO or DO form. Analysis of the completion lengths revealed that these Other responses were significantly shorter than either the PO or DO responses. These analyses excluded cases where the subject had not completed their utterance when the beep sounded to signal the end of the trial, so the production of more Others cannot be attributed to the participants being cut off without completing the sentence. In addition, across all constructions, the participants produced shorter utterances when in the Fast condition. These results suggest that the speakers were choosing to produce shorter utterances in the Fast condition to increase their chances of producing a complete response in the time they had (e.g. 'The student hands the homework in', 'The secretary sends the mail away', 'The barman sends the barmaid home').

It is possible that participants began their Other utterances with the intention of producing a PO or a DO structure; this cannot be ruled out. Levelt and Maassen (1981) concluded that speakers can revise their syntactic decision after speech onset: 'though speakers select an appropriate syntactic frame early in planning their utterance, they can change to another frame during speech itself' (p. 250). It seems plausible that having produced a noun phrase in their completion (e.g. 'The student hands the homework') with the intention of producing a ditransitive sentence, but then finding themselves in difficulty trying to

complete the sentence, participants altered their syntactic plan to produce a shorter utterance (e.g. 'The student hands the homework in'). It is obviously difficult to know whether this is what was happening; however the slight increase in the number of Others produced following PO primes as opposed to DO primes in Expt. 2 might be a by-product of this; a sentence which has begun as a PO is easier to turn into an Other than a sentence which has begun as a DO structure, particularly for the verbs gives, hands, loans and lends. (Intuitively, a sentence such as 'The doctor gives the scalpel' is a lot easier to complete without producing a ditransitive structure than a sentence such as 'The doctor gives the patient'). However, this is a tentative suggestion and cannot be confirmed on the basis of the data presented here. If this account were true, this may predict a greater proportion of dysfluencies in the PO conditions where an Other was produced versus the DO conditions where an Other was produced. However, it would be impossible to know which dysfluencies were due to a PO being switched to an Other or which were due to subjects simply running into difficulty when producing the sentence.

One final factor which is worth considering is the nature of the sentence completion task. The subjects in these experiments were not constrained as to the content of their utterances in the same way that subjects taking part in a picture description task might be (e.g. as in Branigan, Pickering & Cleland, 2000). They were not bound to produce a minimum number of noun phrases. Instead, they were able to alter the content of their completions as much as they liked; and given the pattern of results it appears that they took advantage of this to produce shorter utterances. It is entirely possible that, had they been given a picture description task instead, they may have shown an increased tendency to reuse syntactic structure in the Fast target trials; the slight tendency towards increased priming in speeded conditions suggests this may be the case.

It might be argued then that the sentence completion method is not really analogous to everyday language as the speakers could alter the contents of the sentence to produce a shorter utterance. However, in everyday speech, speakers do not routinely specify all the objects which must be involved in their conceptual representation of the message they are producing. Instead, they produce an utterance which provides sufficient information for the listener to reconstruct their preverbal message (Smith, 2000). For example, sentences such as 'the criminal gave himself up', or 'the student handed the homework in' do

not contain the whole of the message; it is left to the listener to extrapolate that the criminal has given himself up to the police, or the student has handed the homework in to their teacher (however, this is not always selfishly motivated; pairs of speakers will converge on ways of describing objects and coordinate to produce shorter descriptions e.g. Clark and Wilkes-Gibbs, 1986). This is a somewhat speculative account, but the results of the current experiments seem consistent with the view that speakers are for the most part concerned with reducing their own formulation costs, even if this might mean that listeners have to piece together for themselves what the speakers really have in mind.

2.6 Summary

To briefly summarise the main findings of this chapter, two experiments examined the effect of placing subjects under time pressure during a spoken sentence completion task. This was motivated by observations about the effect of reusing syntactic structure on formulation costs, and on research into the time-course of syntactic priming. Across both experiments, there was a weak tendency for speakers to reuse syntactic structure to a greater extent when they were under pressure to produce a sentence quickly. However, the most consistent finding was that speakers produced shorter utterances when under time pressure. This suggests that, while reusing syntactic structure may have some adaptive function in reducing processing costs, speakers prefer to produce shorter utterances when under time pressure.

Chapter 3

Is syntactic information shared between orthography and phonology?

3.0 Overview

This chapter investigates whether syntactic information is accessed in the same way for orthography and phonology. It is implicitly assumed in most current theories of language production that syntactic information is accessed before orthography and phonology and therefore in the same way for each (e.g. Levelt et al., 1999); however, I will review recent research which questions this assumption (e.g. Caramazza & Miozzo, 1997). In Experiments 3, 4 and 5, participants completed sentence fragments in both the spoken and written modality. As in Chapter 2, the sentence fragments were designed so that the magnitude of syntactic priming could be measured (from Pickering & Branigan, 1998). The magnitude of between and within modality priming was compared. The magnitude of priming was not significantly affected by whether the prime and target sentences were produced in the same or different modalities. This is consistent with the view that syntactic information is represented at a modality neutral lemma level, intervening between conceptual and word-form levels.

3.1 Introduction

On first appearances, writing and speaking are very different processes: speaking involves the production of sounds whereas writing involves the production of marks on paper. Speaking is a skill available to virtually all people, whereas writing is a learned skill that takes years to master for those who have the opportunity to learn it. Speaking and writing clearly involve very different forms of expression, and involve different time courses; it takes longer to write a sentence than to say it. What is not clear is the extent to which speaking and writing share the earlier, underlying processes of language production.

At the conceptual level, there may be some differences between writing and speaking. For example, the process of writing an essay bears little resemblance to the process of speaking as part of a conversation in a social setting. However, the process of preparing a speech bears similarities to writing an essay, and a 'conversation' over email may bear a closer resemblance to spoken language than to a written

letter. It may be that there is instead a contrast between formal or prepared language, and informal or unprepared language (Biber, 1988). Other differences between writing and speaking are even less clear; for instance, writing tends to be grammatically more complex than speaking, but it is difficult to say whether this is due to a difference at the level of conceptual planning, or a difference in later syntactic processes. However, broadly speaking, it seems likely that accounts of spoken language production may be applicable to accounts of written production; the same kinds of sentences that are grammatical in spoken production are also grammatical in written production. This chapter is concerned with whether syntax is accessed during speaking (i.e. for phonology) in the same way as it is accessed during writing (i.e. orthography). The major theories of spoken language production (e.g. Garrett, 1988; Levelt, 1989; Dell, 1990) postulate that the formulation process for speaking proceeds through separate stores of semantic, syntactic and word-form information, with varying degrees of interactivity between the three. The evidence cited to support this approach comes from a number of sources including speech errors (e.g. Dell, 1990; Fay & Cutler, 1977; Fromkin, 1971; Garrett, 1975, 1980; Stemberger, 1985), tip-of-the-tongue (TOT) studies (e.g. Vigliocco et al., 1997, 1999), picture naming and lexical decision tasks (e.g. Jescheniak & Levelt, 1994; Schriefers et al., 1990; Schriefers, 1993) and brain-imaging studies (e.g. Van Turrenout et al., 1998) (see Chapter 1 for a review). Syntactic information is represented separately from, and intervening between the semantic and word-form levels. It is implicitly assumed that this information is modality neutral, hence the same store of syntactic information is accessed for written and spoken production. The assumption that the spoken language model can be applied to written production is not new (e.g. Pickering & Branigan, 1998); the finding that syntactic priming occurs in written production is suggestive that the mechanisms behind grammatical encoding in written production are at least similar to those for spoken production. In addition, this priming appears to be influenced by some of the same factors as syntactic priming in speaking; for instance, priming is elevated when verbs are repeated between prime and target sentences in both written (e.g. Pickering & Branigan, 1998) and spoken production (although, as part of a dialogue task; Branigan, Pickering & Cleland, 2000). The relevance of syntactic priming to this issue will be returned to; however first I will outline a model which stands in contrast to

those mentioned previously in that it postulates that syntax is accessed differently for writing and speaking.

3.2 Independent Network model of lexical access

Recently, Caramazza and colleagues (e.g. Caramazza & Miozzo, 1997; Caramazza, 1997; Shelton & Caramazza, 1999) have proposed a model of language production which they label the Independent

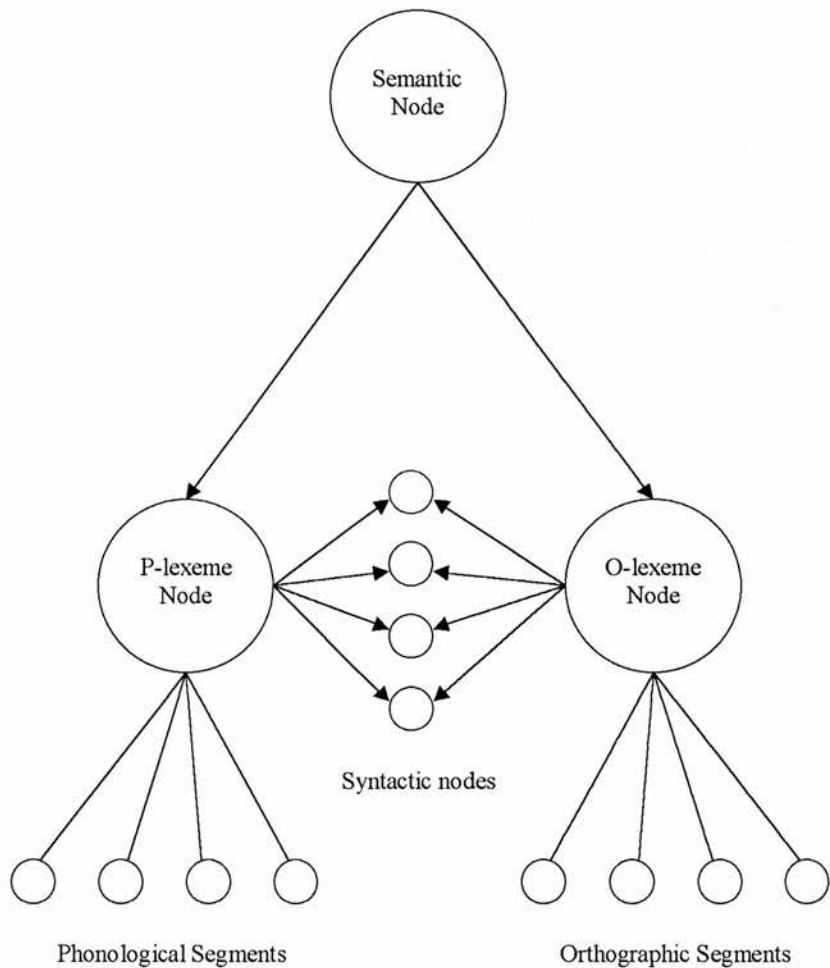


Fig. 9. IN model of language production (based on Caramazza & Miozzo, 1997)

Network model of lexical access (henceforth IN, see Fig. 9). As with the lemma models, they postulate that there are distinctions between semantic, syntactic and word-form information; however, they argue that access to the word-form level is not mediated by access to an intervening syntactic level. They instead postulate the IN model, where semantic representations map directly onto separate phonologically and orthographically specified representations, or P- and O- lexemes, which are connected to a shared store of syntactic nodes. The lexemes in the IN model correspond to lemmas in a lemma model in that they are linked to syntactic and word-form information; however, the lexemes in the IN model are represented at the same level as the syntactic nodes, so there is no lexical level where semantic and syntactic information are represented independently from word-form information. In addition, separate P- and O- lexemes represent phonological and orthographic information, so there are separate formulation processes for speaking and writing.

In the IN model, activation proceeds from the semantic level, with semantic representations activating in parallel all lexemes that share semantic properties (based on Caramazza & Miozzo, 1997). Semantic activations can also weakly activate those syntactic features which have some semantic relevance, for example natural gender. According to Caramazza and Miozzo, the lexemes activate and allow selection of their associated syntactic features, as well as the word-form information. Hence, while syntactic information is shared between the O- and P- lexemes, it is activated separately for each. Activation in the IN model is feedforward only, but cascading.

The most striking features of the IN model are the lack of an intervening lemma level between the semantic and word-form information, and the fact that phonology and orthography are accessed separately. For the first point, Caramazza et al. argue that it is not necessary to postulate a lemma level to account for the existing experimental data; and that in fact there is some evidence (particularly from neuropsychological data) which is inconsistent with the lemma model, or 'syntactic mediation' hypothesis. For the second point, Caramazza et al. argue that there is good motivation for maintaining separate representations for orthography and phonology, based on the deficits shown by some neuropsychological patients. I will review these issues in turn, as well as the counter-arguments against the IN model as presented by Roelofs et al. (1998).

3.2.1 TOT data

Speakers in a TOT situation can often produce partial information about the word which they are trying to recall. Speakers who experience TOT in the course of normal production, or patients who have anomia may be able to access a word's grammatical gender or be able to say whether a noun is a count or mass noun without being able to access word form information (e.g. Vigliocco et al., 1997; Vigliocco et al., 1999; Badecker et al., 1995; see chapter 1 for a review). According to lemma model of language production, the effects observed in TOT studies are a consequence of a speaker having access to a word's lemma but not its lexeme, hence speakers placed in a TOT state can produce the syntactic features of a word such as grammatical gender or mass and count information without being able to access its word-form. However, Caramazza and Miozzo (1997) argue that this data is also consistent with the IN model. The IN model postulates separate stores for word-form information and syntactic information; therefore, it is possible to have access to one without the other. For example a speaker may have access to gender information at the syntactic nodes but experience a failure to select word segment information at the P-lexeme. This would result in the speaker being able to produce the correct gender of a word without any phonological information. Specifically, Caramazza and Miozzo state that this provides an account of the data without resorting to an additional layer of lexical access at the lemma level.

Caramazza and Miozzo (1997) and Miozzo and Caramazza (1997) presented TOT studies which examined the correlation between the correct retrieval of gender and the correct retrieval of an initial phoneme in Italian speakers in an induced TOT state. Subjects were given definitions and asked to produce words to match the definition. If they found themselves unable to produce the word but felt that they did know it, they were asked to provide any gender or phonological information which they could recall. Caramazza and Miozzo found that participants could correctly produce partial information about the noun they were trying to recall; however there was no correlation between the correct retrieval of grammatical gender, and the correct retrieval of an initial phoneme. In addition, successful retrieval of grammatical gender was no more common than successful retrieval of partial phonological information. Caramazza and Miozzo argued that a lemma driven model would predict that the correct retrieval of an

initial phoneme would necessitate the correct retrieval of grammatical gender; as the lemma level intervenes between semantic and word-form information, access to word-form information must imply that a speaker has access to the word's lemma, and therefore syntactic information. However, Caramazza and Miozzo found that successful retrieval of partial phonological information was not dependent on successful retrieval of syntactic features. In addition, they argued that a lemma model would predict that correct retrieval of grammatical gender should be more frequent than correct retrieval of phonological information, as grammatical information precedes word-form information. However, this was not the case. Caramazza and Miozzo argue that the data is inconsistent with the 'syntactic mediation' hypothesis of a lemma level.

Caramazza and Miozzo argued that the IN model can accommodate the finding that speakers can have access to phonological information without access to syntactic information, as syntactic information and phonological information are represented at the same level. In the case where a speaker has access to partial phonological information without syntactic information, there must be a failure of retrieval at the syntactic nodes in the face of successful retrieval of phonological segment information represented at the P-lexeme. Hence, the speaker can produce partial phonological information about the word, but not syntactic information. Caramazza and Miozzo concluded that the IN model is consistent with TOT effects where speakers have access to syntax but not phonology, and when the speaker has access to phonology but not syntax. However, they argued that a model which postulates syntactic mediation between semantic and word-form levels could not account for both types of TOT.

In a reply to this research, Roelofs, Meyer and Levelt (1998) took issue with the assumption that selection of a lemma node necessarily implies selection of grammatical information; they argued that there is a distinction between *activation* and *selection*, and that activated information is only selected when it is needed. So, it is possible for a speaker to have selected the lemma of a word without necessarily selecting the grammatical information associated with it. They cited the results of picture-word interference studies to support this stance. When speakers were asked to produce a noun phrase including a determiner which shares the same grammatical gender as a distractor, production latencies were shorter than when the noun and distractor differed in gender (Schriefers, 1993). However, when speakers are asked to produce bare

nouns, the grammatical gender of the distractor had no effect on production latencies (Jescheniak, 1994). This suggests that speakers do not necessarily access the grammatical gender of a word when they do not need it; otherwise an effect of gender on production latency would be expected regardless of whether a determiner was produced. Roelofs et al. therefore concluded that a speaker could indeed access a word's lemma without necessarily accessing its corresponding grammatical gender, hence the situation where a speaker has access to an initial phoneme without access to gender is no longer problematic. A TOT state where a speaker had access to word-form but not syntactic information would be accounted for as a failure of information selection at the lemma level.

Vinson and Vigliocco (1999) presented two simulations of models which postulate sequential access of syntactic and phonological information. This was to investigate the dependency of phonology on syntax in TOT states. One was based on an interactive model (Dell, 1986) where activation was permitted to cascade from lemma to lexeme, as well as allowing feedback from the lexeme to the lemma. The other was based on Levelt et al. (1999) in that there was no feedback from the lexeme to the lemma level, and full lemma selection was required before lexeme activation. The empirical data from 6 TOT studies was simulated (Expts. 1 and 2 from Caramazza & Miozzo, 1997; Expt. 1 from Miozzo & Caramazza, 1997; Vigliocco et al., 1997; Vigliocco et al., 1998; Gonzales & Miralles, 1997). Vinson and Vigliocco found that both models consistently produced a null correlation between syntax and phonology. In the Dell model simulation, there was a high level of association between lemmas and lexemes, but a low level of association between syntax and phonology. The Levelt model simulation consistently produced uncorrelated syntax and phonology, despite the fact that a TOT state could occur only after a lemma was selected. Vinson and Vigliocco concluded that Caramazza and Miozzo's rejection of syntactic mediation models was premature, as their analysis of the TOT results had lacked the statistical power to detect a dependency between phonology and syntax.

3.2.2 Picture-word interference studies

Picture-word interference studies have been cited as supporting the lemma based accounts as they tend to demonstrate early effects of semantic interference, but later facilitative effects of phonology (e.g.

Meyer, 1996; Schriefers et al., 1990; Meyer & Schriefers, 1991, see Chapter 1 for review). However, Caramazza and Miozzo argue that *any* model which postulates separate stores for semantic and word-form information, and recognises that semantic activation occurs before word-form selection, is sufficient to account for the seemingly early semantic but late phonological effects observed. As the IN model includes separate stores for semantic and word-form information and semantic activation precedes word-form selection, it can account for the results without resorting to a lemma level. Caramazza and Miozzo stress that again it is not necessary to suggest an additional level of lexical representation to account for the data.

3.2.3 Frequency Effects

In their critique of the IN model, Roelofs et al. argued that homophone frequency effects (Jescheniak & Levelt, 1994) are inconsistent with the IN model. In a picture naming task, Jescheniak and Levelt found that low frequency (LF) homophones with a high frequency (HF) twin behaved like HF controls in terms of production latencies. They argued that the LF words had ‘inherited’ the high frequency of their homophone twin. While homophones have separate lemmas, they can share lexemes. If word frequency was encoded at the lemma level, then LF homophones would have behaved like LF controls, as the LF and HF homophones should have separate lemmas. As this was not the case, Jescheniak and Levelt argued that frequency is encoded at the lexeme activation threshold.

In the IN model, homophones have separate lexemes (Caramazza & Miozzo, 1997). As there is no other level of lexical representation, the effects observed by Jescheniak and Levelt must necessarily reflect processes at the lexeme level, or at the level of representation of phonological segments. If word frequency were encoded at the lexeme node, and given that the IN model postulates separate lexemes for homophones, the IN model would predict that LF homophones would behave as LF words in terms of production latencies. However Jescheniak and Levelt did not find such an effect. Without allowing another level of lexical access, Roelofs et al. argue, the IN model cannot account for the data. According to Roelofs et al., the alternative possibility that the homophone effects were a result of phonological segment frequencies appears unlikely, based on Levelt and Wheeldon (1994), who found word frequency effects with word sets that were matched for both syllable and segment frequencies.

To counter this, Caramazza and Miozzo (1998) have argued that their model might allow for a degree of interactivity between the lexical and segmental layers, which might account for LF homophones behaving as their HF twins, as activation of a HF homophone may lead to feedback from the segmental nodes to the LF homophone lexeme.

Roelofs et al. also appealed to the observation that verbs appear to have different lemmas but shared morpheme nodes when in combination with other words. For example, Roelofs et al. (1998) found that the production latency of a verb-particle combination such as 'opgeven' (give up) depended on the frequency of the verb 'geven' in isolation, despite the fact that 'geven' behaves syntactically differently in 'opgeven' than it does in isolation, suggesting that 'geven' is represented at two separate sites of representation.

3.2.4 ERP Studies

Recently, event-related brain potential (ERP) recordings have been used to study the time course of language production (van Turennout et al., 1998; 1999; Schmitt et al., 2001; see chapter 1 for a review). The data from these studies suggested that conceptual processing occurred before syntactic encoding (Schmitt et al., 2001) and that syntactic processing preceded phonological processing (van Turennout et al., 1998, 1999).

Roelofs et al. argued that while the van Turennout et al. (1998) results are consistent with the lemma model, they are not so consistent with Caramazza and Miozzo's IN model. In particular, they argued that the fact that phonological and syntactic information are represented at the same level in the IN model is inconsistent with the finding that syntactic information is available before phonological information in spoken production. Caramazza and Miozzo have countered that it is false reasoning to use the temporal nature of access to different kinds of information to draw conclusions on the structural dependence of levels of representation. They claim that the IN model could indeed assume that syntactic information is selected earlier than phonological information; the lack of a structural dependence between syntactic and phonological features does not preclude this.

3.2.5 Speech Error Data

Roelofs et al. also claimed that the IN model provides an insufficient account of morphologically complex words. They gave the example of words such as *afterthought*. In a lemma model, *afterthought* would be represented differently at the two lexical levels; once at the lemma level, with specifications for syntactic information, and separately at the lexeme level for nodes specifying the word's morphemes *after* and *thought*. Roelofs et al. argue that Caramazza and Miozzo have failed to provide an account of how such words might be represented in the IN model.

In addition, Roelofs et al. raise the point that morphemic errors have been an important aspect of the argument for lemma models. Different types of error are accounted for by proposing different stages of formulation and different levels of lexical access (see Chapter 1). For example, a word exchange such as '...that I'd hear one if I knew it' for 'that I'd know one if I heard it' (Garrett, 1980) is attributed to a lemma exchange. These exchanges typically involve words of the same grammatical class and the fact that the words exchange independently of their morphophonological specifications (i.e. tense for the positions in the sentence remains) suggests that the exchange occurs at a level where a word's number parameters have been set but its word-form has not been retrieved. In contrast, morpheme exchanges such as 'slicely thinned' (Stemberger, 1985) are contained within the same phrase, and may involve words of a different grammatical class. A lemma account would postulate that these errors involve errors at the lexeme level. Roelofs et al. pointed out that the IN model may have problems accounting for both types of error while maintaining only one level of lexical access.

Vinson and Vigliocco raised another problem for the IN model relating to speech errors. In an analysis of a Spanish corpus (Del Viso, Igoa & Garcia-Albea, 1987), they found that for phonological word substitution errors, the intruding word had the same grammatical gender as the word it replaced in over 95% of cases (cf. Marx, 1997 for similar findings in German). Vinson and Vigliocco argued that this is entirely consistent with a lemma model where syntax is retrieved before phonology, as the gender of a word is specified before its word form is retrieved. However, as syntax and phonology are retrieved

independently in the IN model, it is not consistent with the finding that grammatical gender constrains these errors.

3.2.6 Neuropsychological Data

Neuropsychological data which demonstrate the existence of modality specific effects in the spoken and written production of aphasic patients (e.g. Caramazza & Hillis; Rapp & Caramazza, 1997) have been cited as justification for the lack of an intervening lemma level in the IN model. Some neuropsychological data support the distinction between syntax and phonology, for example anomic patients who cannot access the phonology of a word despite having the ability to access its syntactic features (e.g. Henaff Gonon et al., 1989; Vigliocco et al., 1999). These deficits are analogous with the TOT phenomena observed in normal speakers, and are consistent with both the lemma and IN models based on the same reasoning that the TOT data is consistent with both of them, in that both models postulate separate stores for syntax and phonology. In both models, speakers can have access to syntactic features or phonological information without necessarily having access to the other. So, according to the lemma model, an anomic patient who can access the syntactic features of a word but not its phonology would experience a failure at the lexeme level while still having access to the syntactic level. According to the IN model, the same patient would have access to the syntactic nodes, but experience a failure accessing the phonological segments of the word.

Caramazza and Miozzo argued that there are some other deficits in the neuropsychological literature which are compatible with the IN model, but inconsistent with the assumptions of the lemma based models. For example, there is some indirect evidence that brain-damaged subjects can access phonological information without having access to syntactic information. Miceli and Caramazza (1988) described patient FS who could access the phonological form of words, but had difficulty retrieving syntactic features. This suggested that access to phonological information is not dependent on the prior access of syntactic information, therefore suggesting that there is no intervening level between semantics and phonology where syntactic information is represented, as in a lemma model. This is inconsistent with the lemma hypothesis as long as it is assumed that activation of a lemma always results in selection of its

corresponding syntactic features; however, it should be noted that Roelofs et al. suggest this is not always the case in their account of the TOT literature, so presumably the neuropsychological results can be accounted for in the same manner (cf. Vinson & Vigliocco, 1999).

Caramazza and Miozzo cite evidence from patients who make semantic errors in only one output modality (e.g. Caramazza & Hillis, 1990). These patients have a full understanding of the word they are attempting to produce, and their ability to process the meaning of words is unimpaired in that they produce the correct definition of words for which they make semantic errors in reading aloud, and they produce the correct written name for pictures for which they make semantic errors in spoken naming. Caramazza and Miozzo argue that since the deficit is not therefore located at the semantic level, it must be at the level of lexical selection; as the errors are lexical substitutions, the locus of damage is not at the phonological level. In addition, as the errors are restricted to one modality of output, there must be no mediation by a modality neutral representation (i.e. a lemma). In other words, the case against the lemma based models hinges on the fact that these semantic errors would have to be located at the lemma level as the patient's semantic understanding is preserved; however, the fact that the deficits are modality specific suggests that the deficit *cannot* be at a modality neutral lemma level. In summary, Caramazza and Miozzo argue that the lemma based models do not have a level of representation where a deficit would result in the pattern of results observed. The same results are consistent with the IN model. As the IN model represents the orthographic and phonological lexeme levels separately, it can account for the results by locating the deficit at one or the other. So, for example, a patient who makes semantic errors in spoken naming but not written naming would experience a failure at the P-lexeme but not the O-lexeme.

Roelofs et al. (1998) argued that the pattern of results was not necessarily inconsistent with the lemma models. One possibility recognised by Roelofs et al. (1998) would be to propose a modality specific lemma; hence, there would be separate lemmas for written and spoken production, and deficits in one modality could be traced to failures at either the orthographic or phonological lemma. However, such a drastic change to the model may not be necessary. A lemma model can accommodate the results if the locus of damage is placed at the connections between the modality neutral lemma and the modality specific lexemes. Roelofs et al. suggest that in the case of patients who make semantic errors in only one

output modality, there is successful selection of the correct lemma, but then a failure at the connections between the lemma and one of the output modalities (say, phonology). This results in a failure to retrieve the correct word-form. The speaker's need to communicate may lead them to select an alternative, semantically related lemma, and then produce its corresponding form, so producing a semantic substitution error in that modality.

This account releases the lemma model from the problem of the modality specific errors, but Caramazza and Miozzo (1998) raised the point that the lemma models are supposed to have a built-in verification process which functions to detect errors (e.g. Levelt, 1989) and that this monitoring system would prevent the speaker from producing a semantic error. This system must be functioning as it is effective in the other modality, and Caramazza and Miozzo argue that speakers would be more inclined to produce a negative response as they would be aware that their response was wrong. Given that the nature of the monitoring system is not well understood, this objection seems somewhat tenuous without a more specific account of how it might function; for example it is not clear whether the same monitoring system would indeed be relevant for written and spoken output. In addition, it may be that the patients are aware they are producing the wrong responses, but are trying to provide the most accurate response they can.

In addition to the patients who make semantic substitution errors in one modality, Caramazza and Miozzo cite the cases of brain-damaged speakers who appear to show selective deficits in one grammatical class but only in one modality. For example, Caramazza and Hillis (1991) described the patient SJD who has difficulties producing verbs in written but not spoken output, yet can produce nouns equally well in both modalities. This contrasts with the patient HJW who has greater difficulty producing verbs than nouns in spoken output, but has little problem with written production of either verbs or nouns. As the deficit is related to syntax, Caramazza and Miozzo argue that the locus of damage must be at the lemma level. However, given the assumption that the lemma is modality neutral, this could not account for the fact that the deficits are modality specific. The IN model represents orthographic and phonological lexemes separately and is therefore consistent with the data by placing the locus of damage at the links between either the O-lexemes and the syntactic nodes in the case of SJD, or the links between the P-lexemes and the syntactic nodes in the case of HJW. As with the case of the semantic substitution errors

however, a lemma model could remain consistent with the data either by postulating a modality specific lemma, or, more likely, by placing the locus of damage at the links between the modality neutral lemma and a modality specific word-form representation. Hence, in the case of SJD, the locus of damage would be the links between the lemma and the orthographic lexeme, while in the case of HJW the locus of damage would be the links between the lemma and the phonological lexeme. This accounts for the modality specific deficits while maintaining a modality neutral layer of lexical representation.

To summarise, Caramazza and Miozzo have argued there is a convincing case for dropping the lemma level based on the observations that (i) retrieval of phonological information does not appear to depend on the prior selection of syntactic information, and (ii) the relation between semantic representations and modality specific lexical representations does not appear to be mediated by modality neutral lexical representations (according to Caramazza and Miozzo's interpretation of the data).

3.2.7 The phonological mediation hypothesis

The IN model postulates separate sites for the representation of orthographic and phonological word-forms. This approach relies on the assumption that written production does not necessarily proceed through phonology, an issue which is by no means settled in either production or comprehension. There is some evidence that phonological representations are accessed before word-recognition in comprehension, suggesting that comprehension proceeds through phonology (e.g. Van Orden, 1991; Van Orden et al., 1988, 1992; Lukatela & Turvey, 1994a, 1994b; Bosman & de Groot, 1996) whereas others have argued for a 'dual-route' where phonology is not necessarily accessed as a route to orthography in both comprehension (e.g. Coltheart & Coltheart, 1997; Hanley & McDonnell, 1997; Rapp & Caramazza, 1997; Rapp et al., 1997; Miceli et al., 1997). Similarly, there is evidence of an independence of orthography and phonology in production (e.g. Caramazza et al., 1983; Hanley & McDonnell, 1997; Caramazza & Hillis, 1990, 1991; Miceli et al., 1997; Rapp et al., 1997; Shelton & Weinrich, 1997). In a 'dual-route' theory, access of orthography and phonology can be independent. Importantly, writing is not necessarily mediated by the prior access of phonological representations.

A phonological mediation hypothesis of language production would hold that writing proceeds through phonology, so the writer first accesses the phonology of a word before producing its written form. There is indeed some evidence that phonology plays an important role in at least the comprehension of written words (e.g. Lukatela & Turvey, 1994a; 1994b). Similarly, it might be argued that in production, phonology mediates between semantics and orthography, so that the phonological form of a word is accessed first, then the orthographic form.

However, there is some evidence from neuropsychological patients that spelling may be preserved in cases where there has clearly been damage to phonological representations. Caramazza cites the cases of patients who make semantic errors in oral naming but not in written naming (Caramazza & Hillis, 1990), or semantic errors in written naming but not in oral naming (Caramazza & Hillis, 1991). The fact that the patients can still retrieve the correct lexical information in one modality implies that their deficits cannot be at the semantic level; therefore the locus of damage must be a modality specific lexical level. Caramazza postulates this site as the modality specific orthographic or phonological lexemes (O- and P- lexemes). As it therefore appears to be possible to have access to a correct orthographic form but not the correct phonological form, this implies that access to orthography is not necessarily mediated by access to phonology.

Barry (1994) observed that no patients had been reported who were completely successful at word writing but failed completely to write nonwords. He suggested that this might hint that phonology was in fact required for writing at least to some extent. However, Shelton and Weinrich (1997) described patient EA who was reported as failing *completely* at writing nonwords to dictation. The important finding was that EA's written picture naming was vastly superior to his oral picture naming, with the majority of errors semantically rather than phonologically related to the correct response. He was very poor at dictation and failed completely at writing nonwords to dictation. It was also found that providing a greater context in written dictation brought his level of ability up to that of his written picture naming. These findings suggest that, given sufficient context, EA could access the semantics and orthography of what he wanted to write, but could not access phonology, resulting in the deficit in oral picture naming. He did not have an internal phonological representation, so could not write nonwords to dictation, but given sufficient

context could use the semantic and orthographic representations as a route to writing his answers. In short, he did not seem to be able to carry out any phoneme-grapheme conversion, and this does seem to suggest that he could not use the phonological codes of words as a route to producing the written word. It therefore seems unlikely that access to O-lexemes is mediated by prior access to P-lexemes. If written production was indeed mediated by phonology, EA could not have successfully produced written responses.

In addition are the cases of patients who produce different written and spoken semantic errors. Rapp et al. (1997) and Miceli et al. (1997) describe patients PW and WMA, who would produce different semantic errors in spoken and written output when asked to name a picture. Strikingly, these responses persisted despite the fact that the written would follow the spoken response, or the spoken follow the written response. So, for example, in a task where PW was asked to name a picture in the order *spoken then written then spoken then written then spoken then written*, he would consistently produce one answer in the spoken case, and another one in the written case. PW could not have used impoverished phonological material to produce these answers, as there was no evidence of phonological distortions in his errors. In the cases where PW produced the correct written form but the incorrect spoken form, it is very difficult to see how phonological mediation would be necessary for writing.

These patients appear to show damage to the semantic component of the lexical system, as well as problems with orthography-phonology and phonology-orthography conversion mechanisms. In these patients there appears to be a complete separation of orthographic and phonological responses. Unlike the patients who do not have access to phonological representations of any kind, these patients do have access to phonological representations, but this access seems to be completely independent of access to orthographic representations.

In summary, Caramazza has cited the deficits displayed by some neuropsychological patients to justify the fact that the O- and P-lexemes are represented autonomously in the IN model with both linking separately to the semantic node. This contrasts with an account where written production would require a progression through the P-lexeme to the O-lexeme.

3.2.8 Syntax and the IN model

Caramazza (1997) came to the conclusion that phonology and orthography are indeed represented separately, and the separate P- and O-lexemes in the IN model reflect this autonomy. The P- and O-lexemes share the same set of syntactic nodes; however, despite the fact that the nodes are shared between the P- and O-lexemes, they are accessed via separate links. This stands in contrast to the lemma model, where syntactic information is accessed in the same manner regardless of the modality of the final utterance, as the process of production does not become modality specific until after syntactic information has been accessed (e.g. Levelt, 1989). The nature of the syntactic representations in the IN model is not yet well defined, particularly when considering the degree to which access of syntactic information differs for orthography and phonology.

Shelton and Caramazza (1999) cite evidence from brain damaged patients with selective grammatical class deficits (e.g. Caramazza & Hillis, 1991; Hillis & Caramazza, 1995b; Rapp & Caramazza, 1997). They also cite evidence from neuroimaging studies (e.g. Fiez et al., 1996; Martin et al., 1996) which suggest that nouns and verbs are represented separately in the brain. Shelton and Caramazza appear to argue that the modality-specific lexical output forms could be independently specified for grammatical class. This would imply that syntactic representation was to some extent modality-specific. It is not clear from the text what conclusion they draw from this:

The distinction between output forms and grammatical information could be realized in (at least) two ways. Modality-specific lexical output forms may be organized according to grammatical class [1]. On this view, words of different grammatical classes would be represented in different areas of the brain. Or, the connections between modality-specific output forms and syntactic nodes representing grammatical class could be damaged [2]. On this view a syntactic node is shared by two output forms. Damage to the connections from a modality-specific output lexicon would result in a grammatical class deficit for that modality. To date, there are no data to differentiate between these possibilities (Shelton & Caramazza, 1999; p.20, numbers added).

The possibilities [1] and [2] are presented as alternatives here. Quite what Shelton and Caramazza mean by [1] is not well defined; however, it suggests that at least in terms of grammatical class, syntactic information is modality specific. It may be that this is consistent with the IN model with modality specific representations mapping onto shared syntactic nodes. However, another interpretation is

that syntactic information is represented at modality specific sites. In this version of the IN model, P- and O- lexemes would be connected to modality-specific syntactic nodes.

3.2.9 Comparison of IN and Lemma Models

Berndt and Haendiges (2000) contrasted the lemma and IN approaches with reference to a brain-damaged patient (JH), but failed to distinguish between them. JH showed deficits in producing verbs but not nouns in both spoken and written naming tasks. Berndt and Haendiges argued that this is consistent with a lemma model, as the locus of damage could be the modality neutral lemma level, resulting in the cross-modal deficit. However, they argued that the results are not so consistent with the IN model, which would have to postulate two separate loci of damage at the modality specific P- and O- lexemes to account for the data. A lemma model also accounts for the fact that JH's verb production improved when he was asked to produce them as words to complete sentences presented auditorily. The provision of syntactic information within the sentence aided JH's production, and supports the hypothesis that there is a shared lemma representation between comprehension and production. Berndt and Haendiges suggest that the IN model could be elaborated to account for the results so that comprehension processes are involved as well, but note that this may be inconsistent with Caramazza and Shelton (1999) which appears to postulate separate representations for comprehension and production.

However, the merits of the two models reversed when JH's deficits in producing verbs within full sentences were considered. There was a divergence between spoken and written outputs in that JH's performance in written output was markedly worse in comparison to spoken output. This is entirely consistent with the IN model as the locus of damage can be placed at the modality specific O-lexeme, resulting in the written deficit; however, the fact that the P-lexeme is preserved is consistent with the relatively preserved spoken output. Berndt and Haendiges argued that the lemma model is less consistent with the difference in written and spoken outputs as it postulates a modality neutral level of syntactic representation. However, as stated before, this conclusion is based on the assumption that the locus of the deficit is at the lemma level; Berndt and Haendiges do not consider the possibility that the difference may be due to problems at the connection between the lemma and modality specific lexeme levels. However to

summarise, Berndt and Haendiges reached the conclusion that neither the lemma model or the IN model emerged as more consistent with JH's deficits.

3.3 Is syntax represented once? - Summary

To summarise, there appear to be a number of ways in which syntactic information might be represented with reference to orthography and phonology. A lemma account such as Levelt et al. (1999) would assume that syntactic information is represented once, at the modality neutral lemma level. Syntactic information is accessed prior to the modality specific word-form information and so the process is identical, regardless of whether the final output is spoken or written (e.g. Levelt, 1989). However, there is also the possibility within a lemma model of representing syntax at modality specific lemma levels (a possibility suggested by Roelofs et al., 1998). Importantly, the modality specific lemma model postulates separate, modality specific, syntactic nodes connected to the modality specific lemmas; unlike, the IN model, the syntactic nodes are *not* shared between the orthographic and phonological representations (see Caramazza & Miozzo, 1998 p. 235).

Unlike the lemma models, the IN model represents syntactic information at the same lexical level as the separate orthographically and phonologically specified lexemes. The degree to which this syntactic information is shared between the P- and O- lexemes is not entirely clear. The standard version of the IN model represents the syntactic nodes as being shared between orthography and phonology with separate links from each; however, it is possible that syntactic information is to at least to some degree represented specific to modality (see Shelton & Caramazza's account of the data, 1999).

In more general terms, the question of the extent to which syntax is shared between orthography and phonology remains unclear. While word-form information is clearly different for written and spoken output, it remains to be seen whether syntactic information overlaps between the two. The fact that writing and speaking are such different processes might imply that syntax is represented separately for each as in one interpretation of Shelton and Caramazza (1999). However, given that written and spoken language obey the same grammatical rules it also seems reasonable to expect that syntactic representations are shared between writing and speaking, either as a shared representation accessed separately for writing and

speaking as in the IN model, or as a modality neutral representation which is accessed the same way regardless of whether the end product is a written sentence or spoken utterance.

3.4 Syntactic priming studies

Syntactic priming is the tendency of speakers to reuse previously processed syntactic structures (e.g. Bock, 1986b; Bock & Loebell, 1990; Hartsuiker & Kolk, 1998; Pickering & Branigan, 1998; Branigan, Pickering & Cleland, 2000, see Chapter 1 for a review). Accounts of the mechanisms behind syntactic priming have placed the locus of priming at the lemma level. Pickering and Branigan (1998) propose an account where the residual activation of syntactic nodes specifying combinatorial information at the lemma level leads to the reuse of the same structures in subsequent utterances. So, for example, the production of a sentence containing a ditransitive verb can result in at least two syntactic structures, depending on how the verb is combined with other words in the sentence. If a speaker produces a double object structure, then a combinatorial node specifying this structure will become activated. If the next utterance contains a verb which can be combined in this fashion, the residual activation of the combinatorial node will result in this structure being reused rather than an alternative.

Caramazza and Miozzo have not produced an account of syntactic priming with reference to the IN model; the IN model has principally been proposed to account for grammatical gender and class. However, it might be assumed that some form of syntactic combinatorial information be stored at the site of the syntactic nodes (cf. Berndt and Haenduijges, 2000). If this were the case, the locus of priming must be the syntactic nodes shared between the P- and O- lexemes, or the links between the syntactic nodes and the P- and O-lexemes. So hypothetically, the activation of a ditransitive verb at the P- or O-lexeme level will trigger the activation of a syntactic node specifying how it may be combined with other words in the sentence. The residual activation of this syntactic node will result in subsequent utterances containing a ditransitive verb selecting the same structure. It has been observed that syntactic priming is reduced when prime and target sentences contain different verbs as opposed to the situation where they share the same verb (e.g. Pickering & Branigan, 1998; Branigan et al., 2000). In a lemma account, this has led to the suggestion that syntactic priming is at least partially due to the activation of links between nodes as well as

the nodes themselves. Similarly, in the IN model, syntactic priming is likely to involve the links between the P- or O-lexeme and the syntactic node as well as the node itself. As different verbs would hold different links but nevertheless access the same syntactic node this would account for the fact that priming is reduced but still present when primes contain a different verb to the target. If priming was due solely to the activation of the syntactic node, there would not be a reduction of priming when the verb differed between prime and target.

An alternative account of the difference between repeated and different verb results is that the greater magnitude of priming in the repeated verb condition is due to the joined higher activation of the lexico-semantic representation of the verb (i.e. the lemma or lexeme in the Levelt or IN model) and its specific syntactic properties (i.e. it's combinatorial node). However, while this account makes no reference to the existence of 'links' between entities, the end result is the same: the joined activation of different nodes results in a higher likelihood of them being selected together. Pickering and Branigan (1998) envision this as being due to strengthening of a link between nodes; for the rest of this chapter I will use the same model.

3.4.1 Between modality syntactic priming

Previous studies of production-to-production syntactic priming have kept the prime and target responses within the same modality, whether that be written (e.g. Pickering & Branigan, 1998; Branigan et al., 1999) or spoken (e.g. Branigan, Pickering, Stewart & McLean, 2000). There is some evidence that there are differences between written and spoken priming; syntactic priming in written production appears to decay fairly rapidly, with priming dramatically decreasing with as little as one unrelated sentence between prime and target (Branigan et al., 1999), whereas priming in spoken production persists for longer (Branigan, Pickering, Stewart & McLean, 2000; Bock & Griffin, 2000). However there are similarities also; there does not appear to be a difference between written and spoken priming when there is no delay between prime and target (Branigan et al., 1999; Branigan et al., 2000b; Hartsuiker & Westenberg, 2000). In addition, priming is increased when verbs are repeated between prime and target sentences both in

written production (Pickering & Branigan, 1998) and spoken production as part of a dialogue task (Branigan, Pickering & Cleland, 2000).

Thus far there has been no research into the effects of placing prime and target in different modalities. As discussed above, none of the models of language production discussed have a problem accounting for a within modality syntactic priming effect. Because syntactic priming reflects activation at the level of syntactic representation, cross-modality priming would have implications for how syntactic information is represented between modalities.

An account which postulates that syntactic information is represented separately for orthography and phonology would not predict a syntactic priming effect to occur when the prime and target were produced in different modalities, as different syntactic representations are accessed in each case and priming depends on the prior activation of syntactic information. There are two versions of this account: one is a modality-specific lemma account, a possibility recognised by Roelofs et al. (1998), and the other is an interpretation of the possibility suggested by Shelton and Caramazza (1999) which would postulate separate sites of syntactic information for orthography and phonology. Neither of these accounts would predict syntactic priming when the prime and target sentences were produced in different modalities, as syntactic nodes are not shared between modalities. This is because neither of them postulate a layer of representation where syntactic information is shared between orthography and phonology. Assuming that priming is due to residual activation of procedures or representations at a syntactic level of representation, it is unlikely that residual activation in one output modality could affect output in another modality in these models.

Models which postulate that syntactic information is shared between orthography and phonology would predict cross-modal priming, as the same store of syntactic information is accessed in each case. As the access of syntactic information is the same in the modality neutral lemma model regardless of whether the final output is written or spoken, it would predict an equal magnitude of priming regardless of the modality of the prime and target sentences. The IN model would predict at least some degree of between modality priming as syntactic information is shared between orthographic and phonological lexemes. However, as mentioned above, if it is assumed that priming involves the links between verb nodes and

syntactic nodes as well as the activation of the nodes themselves, then the IN model would predict that priming should be reduced when the prime and target differed in modality, as the P- and O-lexeme nodes have different links to the syntactic nodes. To put this another way, when the target is in the same modality as the prime, residual activation of the P-lexeme and the syntactic node will result in the priming effect; when the target is in a different modality, there will still be residual activation of the syntactic node but not of the O-lexeme because the prime sentence involved the P-lexeme.

The following experiments employed the sentence fragment completion technique, which has shown within modality priming in both written (e.g. Pickering & Branigan, 1998; Branigan et al., 1999; Hartsuiker & Westenberg, 2000) and spoken production (Branigan, Pickering, Stewart & McLean, 2000). The experiments employed dative-alternating verbs, consistent with PO or DO sentences. As with Expts. 1 and 2 (see Chapter 2), the wording of the prime fragments was manipulated so that the participants were likely to produce a PO or a DO completion. So, for example, a sentence fragment such as 'The neighbour lends the mower' would be likely to result in a PO completion, whereas a sentence fragment such as 'The neighbour lends the friend' would be likely to result in a DO completion. Target fragments could be completed with either structure e.g. 'The cook lends'. It has already been established that having produced a sentence of one of these types, subjects are more likely to produce a sentence of the same structure on the next trial. Prior to each trial, subjects were given a visual cue as to whether they should produce a spoken or written sentence. Primes were manipulated within the experiments so that they were either written or spoken. The target sentences were spoken in Exps. 3 and 4, and written in Exp. 5. What was of crucial importance was whether syntactic priming would still occur when the prime and target sentences were produced in different modalities, and whether the magnitude of this effect would remain the same between and within modalities.

3.5 Experiment Three

3.5.1 Method

3.5.1.1 Participants

Sixteen students from the University of Glasgow community were paid to participate.

3.5.1.2 Items

Twenty-four experimental items were constructed (see Appendix), each consisting of two sentence fragments: e.g.

- 1a. The neighbour lends the mower (PO-inducing prime)
- 1b. The neighbour lends the friend (DO-inducing prime)
- 2. The cook lends (Target)

The prime and target fragments were designed in a similar manner to those used in Expts. 1 and 2 so that the primes were likely to elicit a PO or a DO construction, and the target fragments could be completed with either construction. The prime and target fragments employed the same six verbs (*gives, hands, loans, shows, lends* and *sends*), and the prime and target fragment always contained the same verb. Because some of the subjects responses were written, the sentences contained plain nouns with no adjectives or adverbs. As written responses take longer to complete, there was a worry that a reduction in priming between modalities might be observed which was due to decay (Branigan et al, 1999); hence it was desirable to reduce the time for each response as far as possible.

Each prime fragment appeared in a spoken and a written form. Target fragments were always spoken. Thus, the prime sentences were presented in four conditions:

Spoken PO-inducing
 Spoken DO-inducing
 Written PO-inducing
 Written DO-inducing

Four lists of items were constructed, such that each list contained six items from each condition, and one version of each item. Each list also included 96 filler fragments, consisting of 42 noun phrases, 27 noun phrases plus verbs, and 27 noun phrases plus verbs plus noun phrases. No ditransitive verbs were used in the fillers, so that the subjects' responses in the filler fragments would be unlikely to influence their responses on the experimental items. The proportion of spoken responses to written responses in the experimental trials was 3:1, as the target was always spoken but the prime varied. This proportion was maintained for the filler fragments as well so that the experimental items would not stand out from the rest of the experiment. The lists were individually randomised, with the constraint that at least 3 fillers intervened between each item.

The randomised lists were then entered into a PsyScope program (Cohen, MacWhinney, Flatts & Provost, 1993), which was designed to display each sentence in turn, and to provide a cue depending on whether the sentence was to be written or spoken. Unlike previous studies, the program was designed so that it presented sentences on the screen until the subjects pressed the space bar. Again, this was because some of the responses were written and it would be difficult to assign a presentation time to the written sentences which would suit all participants.

3.5.1.3 Procedure

As for Expts. 1 and 2, the experimental files were presented on a Macintosh computer using PsyScope software (Cohen, MacWhinney, Flatts & Provost, 1993). Participants were seated in front of the computer in a quiet booth and were given a set of written instructions. They were told that the experiment was concerned with what kinds of sentences people produce and that their task was to complete the sentences as quickly as possible, with the first grammatical completion that came to mind. They were also

told that they would either be expected to write down the sentence fragments and complete them, or read them out loud and complete them, and that a prompt would let them know which they were to do.

On each trial, a prompt first appeared for 2000ms indicating whether a written or spoken response was required. If a written sentence was required, the following prompt appeared:

If a spoken response was required, the following prompt appeared:

+++++

These prompts were presented in red. The reason for this was that presenting the prompts in a different colour to the text distinguished them from the rest of the experiment, and it was important that participants paid attention and produced each sentence in the correct modality. Next a fixation point (a black *) was presented for 500ms. Finally, the sentence was presented, with the first letter of the sentence appearing at the fixation point. After completing the sentence, the participant pressed the space bar to move onto the next trial, at which point the sentence fragment disappeared from the screen. Participants were provided with a folder of paper for written completions, and told to write one sentence per page and to fold over the page after each completion. Spoken responses were tape recorded. The experiment lasted about 35 minutes, and contained no breaks. A practice session of five sentences preceded the experiment proper, and participants were given the chance to ask questions about the procedure.

3.5.1.4 Scoring

The participants' responses to the experimental items were transcribed from the tape recordings, and their written responses were inserted into the transcription at the point they were presented during the experiment. The responses were scored as PO, DO or Other, using the same criteria as that used in Expts. 1 and 2.

3.5.1.5 Design and data analysis

Every participant completed 24 target fragments, six in each of the four priming conditions defined by the two levels of the Prime Completion factor (PO vs. DO) and the two levels of the Modality

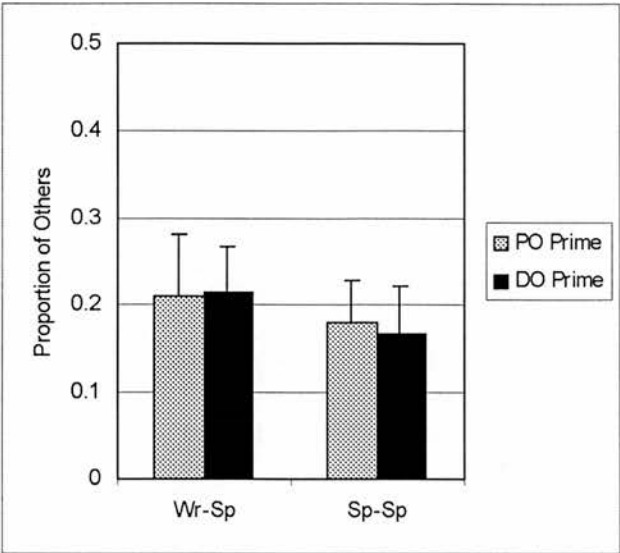
factor (written vs. spoken). Every experimental item was presented to all sixteen participants, with four participants seeing any one version of an item.

As for Expts. 1 and 2, the results were first analysed for Other responses, to determine whether the combined proportion of PO and DO target responses was comparable across priming conditions. Thus, the proportions of Other responses following written PO prime completions, written DO prime completions, spoken PO prime completions, and spoken DO prime completions were compared. The relevant proportions were calculated using the same method as Expts. 1 and 2. Analyses of variance were performed on these data, with separate analyses treating participants (F1) and items (F2) as random effects. The analyses were within-participants and within-items.

The PO Target Ratio was then computed to determine the relative proportions of PO and DO target responses in each of the priming conditions using the same procedure as Expts. 1 and 2.

3.5.2 Results

Participants produced a PO or DO completion for the prime fragment on 88% of trials; of these, 21% were written PO completions, 26% were written DO completions, 26% were spoken PO completions, and 27% were spoken DO completions. ANOVAs on the proportion of Others revealed that there were no significant effects of condition (all $F_s < 1$). For the proportions of Others produced across the experimental conditions, see Fig. 10. Again, all graphs present data from the subjects analysis, and error bars represent standard error values for the subjects analysis. Values are reported to two significant figures.



Wr-Sp: Written prime; Spoken target, Sp-Sp: Spoken prime; Spoken target

Fig. 10. Proportions of Others produced in Expt. 3.

ANOVAs on the PO target ratio revealed an effect of Prime Completion ($F(1,15)=52.06$, $p<.001$, $MSe=.035$; $F(1,23)=14.69$, $p<.01$, $MSe=.16$). There was an overall priming effect of 34% (i.e. 34% more target completions were of the same structure as the prime completion than were of the alternative structure). However, there were no other effects. In particular there was no significant interaction of Prime Completion by Modality ($F(1,15)=.39$, $p=.54$, $MSe=.040$; $F(1,23)=.46$, $p=.50$, $MSe=.19$). When the prime and target were within the same modality the magnitude of priming was 31%; when they differed in modality the priming level was 37%. See Fig. 11 for a summary of the PO Target Ratios produced.

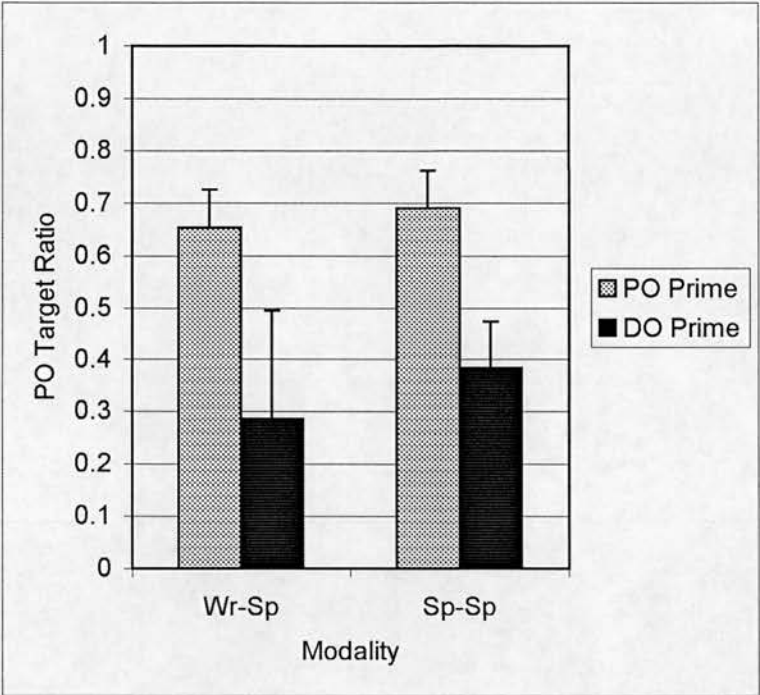


Fig. 11. PO Target Ratios for Expt. 3.

3.5.3 Discussion

Expt. 3 replicated the syntactic priming effect, in that participants were significantly more likely to produce a target utterance which was of the same syntactic structure as the prime utterance than was of the alternative structure; overall, they produced 34% more utterances of the same construction as the prime than the alternative. This is consistent with the finding of syntactic priming in the literature (e.g. Bock, 1986b; Pickering & Branigan, 1998; Hartsuiker & Kolk, 1998).

Crucially, the magnitude of this syntactic priming effect was not influenced by whether the prime sentence was in the same or different modality to the target sentence (there was a 37% between modality syntactic priming effect, and 31% within modality effect, and there was no significant interaction of modality by prime construction). So, written prime responses primed spoken target responses as well as

spoken prime response primed spoken target responses; in fact the magnitude of priming was numerically larger in the between modality condition.

This finding is consistent with the hypothesis that syntactic information is accessed in the same way for spoken and written production; as the locus of syntactic priming is likely to be the level of syntactic representation, the same syntactic representation must have been accessed when the prime was written as when it was spoken. This issue will be returned to in the General Discussion.

Expt. 4 was a replication of Expt. 3 except that instead of the prime and target sentence fragments containing the same verb, they contained different verbs. In part, the motivation behind this was to see if the effects seen in Expt. 3 were replicated. In addition, the observation that priming is reduced when the verb differs between prime and target is part of the motivation for arguing that priming in the IN model must involve activation of the links between verb nodes and syntactic nodes as well as activation of the nodes themselves.

3.6 Experiment Four

3.6.1 Method

3.6.1.1 Participants

Thirty-two students from the University of Glasgow were paid to participate.

3.6.1.2 Items

The same set of items was used as in Expt. 3. The targets remained the same, and the prime sentences were rotated so that the prime and target sentences contained different verbs: e.g.

- 1a. The writer gives the script (PO-inducing prime)
- 1b. The writer gives the publisher (DO-inducing prime)
2. The cook lends (Target)

The same set of fillers were used as in Expt.3.

3.6.1.3 Procedure, Scoring and Design and data analysis

These were all identical to Expt. 3.

3.6.2 Results

Participants produced a PO or DO completion for the prime fragment on 90% of trials; of these, 24% were written PO completions, 26% were written DO completions, 26% were spoken PO completions, and 25% were spoken DO completions. ANOVAs on the proportion of Others revealed that there were no significant effects of condition (all $F_s < 1.2$). See Fig. 12 for the proportions of Others produced across the experimental conditions.

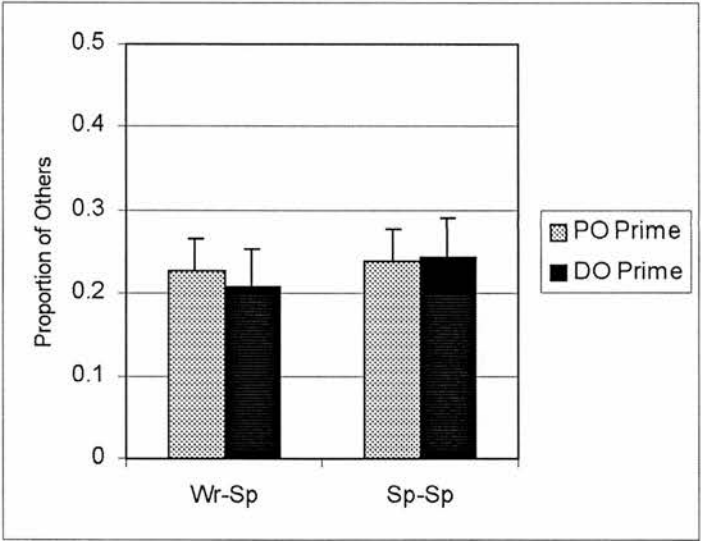


Fig. 12. Proportions of Others produced in Expt. 4.

ANOVAs on the PO target ratio revealed an effect of Prime Completion ($F(1,31)=10.09$, $p < .01$, $MSe=.051$; $F(1,23)=9.97$, $p < .01$, $MSe=.042$). There was an overall priming effect of 13%. However,

there were no other effects. In particular there was no significant interaction of Prime Completion by Modality ($F(1,31)=.66, p=.42, MSe=.042$; $F(1,23)=.64, p=.43, MSe=.050$). When the prime and target were within the same modality the magnitude of priming was 17%; when they differed in modality the priming level was 10%. Fig. 13 provides a summary of the PO target ratios across all conditions.

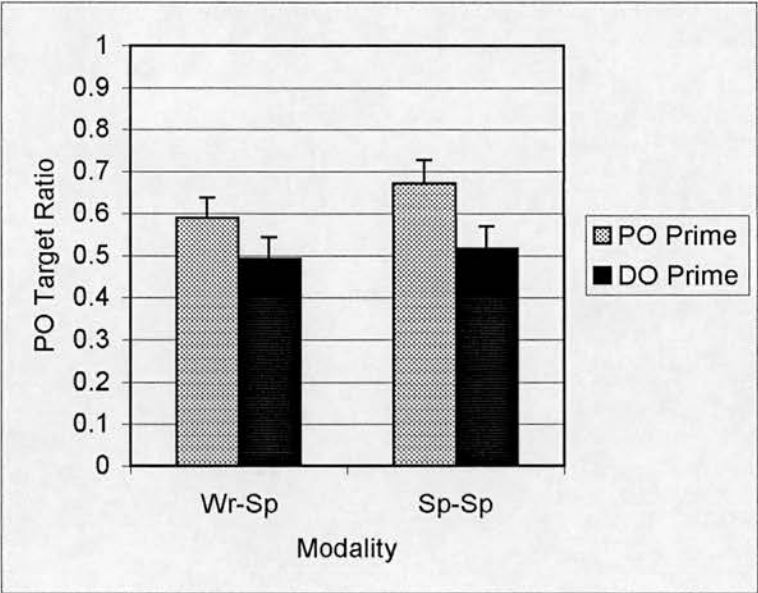


Fig. 13. PO Target Ratios for Expt. 4.

3.6.3 Combined Analysis of Expt. 3 and Expt. 4

A cross experiment comparison was carried out. As the same target items were used in both experiments, the analysis was between subjects but within items. ANOVAs revealed that there was a difference between the overall magnitude of priming in the same and different experiments, marginal by items ($F(1,46)=26.87, p<.001, MSe=.035$; $F(1,23)=3.65, p<.07, MSe=.10$). This replicates previous findings that priming is reduced when the prime and target contain different verbs versus the case where they contain the same verb (e.g. Pickering & Branigan, 1998; Branigan, Pickering & Cleland, 2000). In Expt. 3, where the verb remained the same between prime and target, the magnitude of priming was 34%;

in Expt. 4 where the verb differed between prime and target, the magnitude of priming was 13%. With the two experiments combined, the effect of the modality of the prime remained non-significant ($F < 1$), with a 24% priming effect in both the between and within modality conditions across Expt. 3 and Expt. 4. There were no other significant interactions.

3.6.4 Discussion

Expt. 4 again demonstrated that participants were significantly more likely to produce a target utterance with the same structure as the prime utterance than with the alternative structure; overall, participants produced 13% more utterances of the same construction as the prime than of the alternative construction. In addition, the difference between the within modality priming (17%) and the between modality priming (10%) was non-significant, so written prime responses primed spoken target responses as well as spoken prime responses primed spoken target responses.

A comparison of Expts. 3 and 4 revealed that the difference between the magnitude of priming in Expt. 3 (34%) and the magnitude of priming in Expt. 4 (13%) was significant by subjects, and marginally significant by items ($< .07$). This replicates the finding that the magnitude of syntactic priming is increased when the verb remains the same between prime and target sentences as opposed to the case where it differs (Pickering & Branigan, 1998; Branigan, Pickering & Cleland, 2000).

Taken together, these experiments appear to demonstrate a robust finding of cross-modality priming: analysed together the magnitude of between and within priming remained equivalent at 24%. This is strongly supportive of a model of language production which postulates that syntactic information is shared between orthography and phonology, and is highly inconsistent with accounts with models which postulate separate representations for orthography and phonology. If orthography and phonology accessed different syntactic representations, the syntactic processing of an utterance in one modality should not affect the syntactic processing of an utterance in the other modality. This issue will be returned to in the General Discussion.

Despite the apparently strong finding of cross-modality priming, it was necessary to rule out alternative explanations for the results. One possibility was that the cross-modality priming effect was not

in fact caused by residual activation of syntactic representations shared between orthography and phonology. It was possible that, in the case where the target was spoken and the prime was written, participants were re-reading what they had just written in the written prime responses, thus activating phonological representations. This might lead to activation of the syntactic representations for phonology, and hence lead to an apparent cross-modality priming effect when the speaker subsequently produced a spoken target sentence. To rule out this possibility, Expt. 5 was a repetition of Expt. 3 with the variation that target responses were written instead of spoken, while prime and target responses were either written or spoken. There is no reason for activation of orthographic information to occur during production of the spoken prime sentence, so cross-modality priming could not be explained in terms of activation of orthographic information during prime production.

3.7 Experiment Five

3.7.1 Method

3.7.1.1 Participants

Sixteen students from the University of Edinburgh were paid to participate.

3.7.1.2 Items

The same set of items was used as in Expt. 3; however, the modality of the target fragments was reversed, so that the target was always written, but the prime could either be written or spoken.

3.7.1.3 Procedure, Scoring and Design and data analysis

See Expt. 3.

3.7.2 Results

Participants produced a PO or DO completion for the prime fragment on 89% of trials; of these, 23% were written PO completions, 28% were written DO completions, 24% were spoken PO completions, and 26% were spoken DO completions. ANOVAs on the proportion of Others revealed that there were no significant effects of condition (all $F_s < 1.1$). See Fig. 14 for the proportions of Others produced across the experimental conditions.

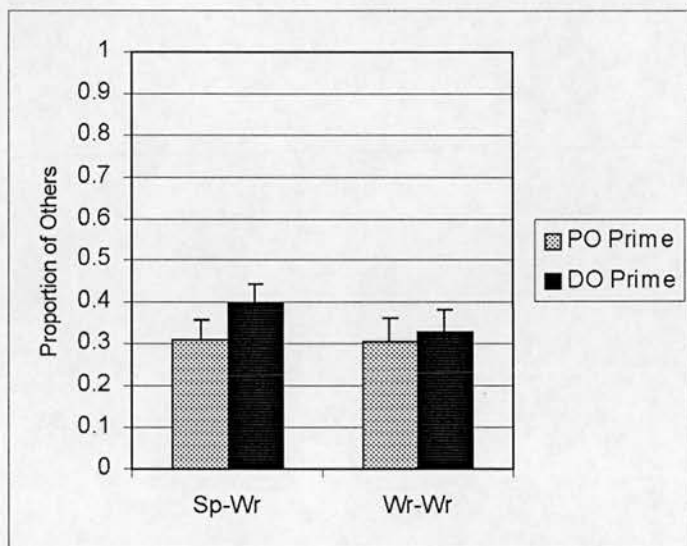


Fig. 14. Proportions of Others produced in Expt. 5.

ANOVAs on the PO target ratio revealed an effect of Prime Completion ($F(1,15)=5.73$, $p < .05$, $MSe=.078$; $F(1,23)=17.70$, $p < .001$, $MSe=.057$). There was an overall priming effect of 17%. However, there were no other effects. In particular there was no significant interaction of Prime Completion by Modality ($F(1,15)=.09$, $p=.77$, $MSe=.043$; $F(1,23)=.20$, $p=.66$, $MSe=.015$). When the prime and target were within the same modality the magnitude of priming was 15%; when they differed in modality the priming level was 18%. See Fig. 15 for a summary of the PO Target Ratios produced.

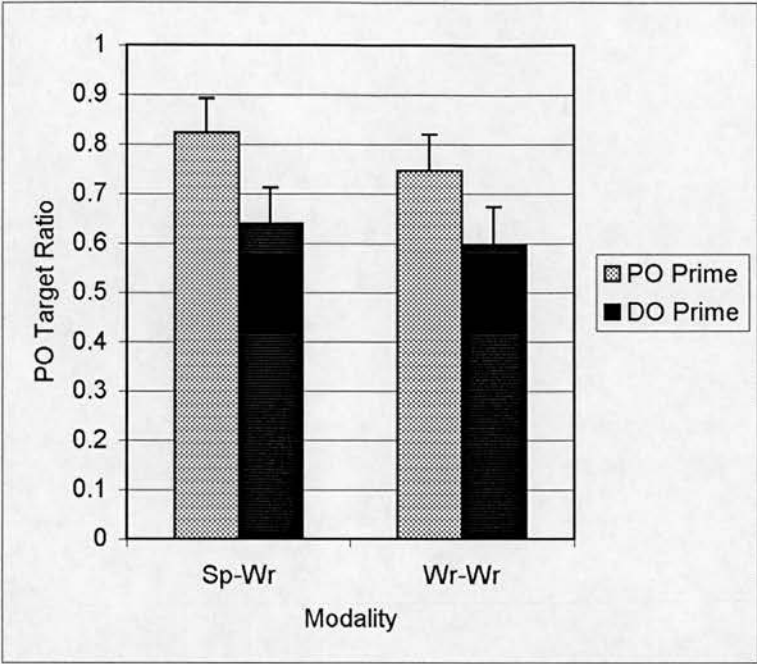


Fig. 15. PO Target Ratios for Expt. 5.

3.7.3 Combined Analysis of Exp. 3 and Exp. 5

A cross experiment analysis of Expts. 3 and 5 was carried out. Expts. 3 and 5 used the same items; the difference between them was that the target sentences were spoken in Expt. 3, while they were written in Expt. 5. Because the target items were the same for both experiments, the analysis was between subjects and within items. ANOVAs revealed that there was a significant difference in the proportion of Others produced in the two experiments ($F(1,30)=6.02$; $p<.05$, $MSe=.16$; $F(1,23)=17.73$, $p<.001$, $MSe=.048$). The proportion of Others produced in Expt. 3 was 0.19, whereas in Expt. 5 it was 0.34.

In addition, ANOVAs revealed that there was a marginally significant difference in the magnitude of priming between Expt. 3 and Expt. 5 by subjects analysis ($F(1,30)=4.09$, $p<.06$; $F(1,23)=.78$, $p=.39$, $MSe=.11$). In Expt. 3, the overall magnitude of priming was 34%; in Expt. 5 it was 17%. This suggests that while the modality of the prime has no effect on the magnitude of priming, the modality of the target may have an effect.

3.7.4 Discussion

Expt. 5 demonstrated again that participants were more likely to produce a target utterance with the same structure as the prime utterance than with the alternative structure; they produced 17% more utterances of the same construction as the prime than of the alternative. Importantly, the magnitude of between-modality priming was not significantly different to the magnitude of within-modality priming (when the prime and target differed in modality, the magnitude of priming was 18%, when they were in the same modality, it was 15%). Again, this finding is consistent with a model of language production which postulates that syntactic information is accessed in the same way for orthography and phonology.

Interestingly, there did appear to be an effect of the modality of the target when Expt. 5 was contrasted with Expt. 3; there was a tendency for the magnitude of priming to be reduced when the target was written (17%) as opposed to the case where it was spoken (34%). In addition, subjects produced significantly more Other completions in the case of written targets. This may be in part due to the fact that a written sentence takes longer to complete than a spoken sentence, and so there was a quicker decay of the priming effect (see Branigan et al., 1999). The longer time it takes to complete a written sentence could also result in subjects producing a shorter utterance so that they could move onto the next trial, resulting in a higher proportion of Other completions (see Chapter 2).

3.8 General Discussion

Experiments Three, Four and Five were designed to investigate the issue of whether syntactic information is accessed in the same way for written and spoken production; while models of language production tend to be described in terms of spoken production, they must also be able to account for written production if they are to provide an adequate account of the language production system. Given that syntactic priming is attributed to activation at the level of syntactic representation, these experiments investigated whether syntactic priming occurs across modalities: from written to spoken sentences, and from spoken to written sentences. If this were to occur, it would mean that models of language production would have to account for how syntactic processes involved in production in one modality could affect syntactic processes involved in production in another modality.

Overall, there was a significant priming effect; across all experiments participants produced more target responses of the same construction as the prime than of the alternative construction. In Expt. 3, there was a 34% priming effect (i.e. 34% more target utterances with the same construction as the prime utterance than with the alternative structure), in Expt. 4 there was a 13% priming effect, and in Expt. 5 there was a 17% priming effect. This is consistent with previous findings in the literature (e.g. Bock, 1986b; Pickering & Branigan, 1998) that people tend to reuse syntactic structure. Importantly, across all experiments, the magnitude of cross-modality priming was not significantly different to the magnitude of within modality priming; in other words, it did not matter whether the prime and target were in the same modality or different modalities – the magnitude of priming remained the same. So, across all 3 experiments, there was a mean 21% priming effect when the prime and target were produced in the same modality, and a mean 22% priming effect when the prime and target were produced in different modalities.

For, spoken targets, the priming effect was reduced when the prime and target sentences contained different verbs as opposed to when they contained the same verb (13% in the former case versus 34% in the latter). This effect is consistent with previous findings in written (Pickering & Branigan, 1998) and dialogue (Branigan, Pickering & Cleland, 2000) priming. Interestingly, there was also a tendency for the magnitude of priming to be reduced when the target was written rather than spoken, regardless of the modality of the prime (34% versus 17%), although this effect was not statistically reliable. In addition, participants produced significantly more Other responses to written target completions than spoken target completions; when the target was spoken, the proportion of Other target completions was 0.19, and when the target was written the proportion was 0.34. There are a number of conclusions to be drawn from these results. Most importantly, the answer to the question ‘Is syntax shared between orthography and phonology?’ seems to be ‘Yes’; the participants were influenced by the prime sentences in the same manner regardless of whether they were spoken or written.

It is necessary to consider the possibility that the cross-modality priming effects were due to factors other than activation of a shared level of syntactic representation. It might be argued that activation of phonological information as part of written production resulted in the cross-modal priming effect. There

are two ways in which phonology might have this effect. The first relates to the phonological mediation hypothesis where phonological information is accessed *before* written production; the second relates to activation of phonological information *after* written production as a result of, for example, re-reading a written sentence.

In the former case, phonological information would necessarily be activated before orthographic information: the phonological mediation hypothesis (e.g. Barry, 1994) postulates that written production is mediated by phonology. In this case, cross-modality priming would be expected. This model does not affect conclusions about a modality neutral lemma model, as the lemma model assumes that syntactic information is accessed before either the phonological or the orthographic word-form is accessed anyway; however, it is inconsistent with the IN model which has the separation of P- and O- lexemes as an intrinsic feature. As such, Caramazza and colleagues have argued against the phonological mediation hypothesis (e.g. Rapp et al., 1997; Miceli et al., 1997).

In the latter case, phonological information may be activated if the subject re-read the sentence they had just written in the prime condition; or it might be argued that, subsequent to producing a sentence in the written modality, phonological representations became activated. Expt. 5 ruled out the possibility that phonological information activated after the written sentence was completed would result in the cross-modality priming. This is because it examined the case where the prime was spoken but the target was written. Even if phonological information were activated after producing the written sentence in the target, this would only occur after the participant had already completed the target sentence and so would not affect the syntactic structure of the sentence. Expt. 5 also demonstrated that the cross-modality priming effect was not due to activation of phonological information after re-reading the prime sentence: the prime sentence was spoken and the target was written, so any activation of phonological information due to re-reading the written sentence would have no bearing on the priming effect.

3.8.1 Modality Specific Syntactic Representations

In the introduction, two models were discussed which might postulate modality specific representations. The first possibility, recognised but not necessarily advocated by Roelofs et al. (1998),

was based on a lemma model. In this model, modality specific lemma representations intervene between the conceptual level and the modality specific word-form representations. Syntactic information is not shared between these modality specific lemma representations. Hence, there are separate representations of syntactic information for orthography and phonology. In a lemma model, the locus of priming is the lemma level, where residual activation of syntactic information results in the repetition of syntactic structures in utterances (e.g. Pickering & Branigan, 1998). In the modality specific lemma model, the locus of priming would therefore be either the orthographic lemma level in writing, or the phonological lemma level in speaking. As these are represented autonomously, this is inconsistent with the finding that cross-modality priming occurs. If the prime and target are in different modalities, then different lemma representations would be accessed for each of them; hence it follows that, as priming is due to activation at the lemma level, there would be no priming effect between modalities. A modality specific lemma account which postulated shared syntactic nodes between orthographic and phonological lemmas would be consistent with the results; however, this account has not been proposed so far in the literature, possibly because it renders the modality specific lemmas obsolete.

The second possibility was based on one interpretation of Shelton and Caramazza (1999), where syntactic information is modality specific; so, modality specific word-form nodes are linked separately to the semantic level, and also to modality specific syntactic nodes. In this model, the locus of priming is presumably the syntactic nodes, as this is the store of syntactic information. It follows that different sets of syntactic nodes are activated depending on whether the final output is a written or spoken sentence. Again, the results are inconsistent with this account; when the prime and target are in different modalities, different sets of syntactic nodes would be accessed, therefore no cross-modality priming would occur.

In order for the results to be consistent with the modality specific models, it would be necessary in both cases for both the orthographic and phonological stores of syntactic information to be activated every time a written or spoken sentence was produced and regardless of the distinction between them. According to this account, an interlocutor would activate syntactic information for orthography separately from but in parallel to phonology while producing a spoken sentence, and activate syntactic information for phonology separately from but in parallel to orthography while writing (and presumably this activation

would have to occur to the same extent for each modality). This scenario seems highly unlikely. In summary then, the results are inconsistent with those accounts which postulate separate stores of syntactic information for orthography and phonology.

3.8.2 The IN Model

The IN model postulates that semantic representations map directly onto separate orthographically and phonologically specified word-form nodes which are connected to a shared store of syntactic nodes (e.g. Caramazza & Miozzo, 1997; Shelton & Caramazza, 1999; see Fig. 1 in introduction). In a model such as this, the locus of priming must be the syntactic nodes. As these are shared between orthography and phonology, the IN model does not have a problem with the finding of syntactic priming between modalities. However, the finding that cross-modality priming was not reduced from within-modality priming may be problematic. A comparison of Expts. 3 and 4 revealed that priming *was* significantly reduced when the verb differed between the prime and target sentence fragments as compared to the case where it remained the same (see also Pickering & Branigan, 1998). As discussed previously, the finding that priming effects are reduced when the verbs differ between prime and target suggests that priming must be due to activation of the links between lexemes and syntactic nodes as well as the syntactic nodes themselves in an IN model. This is because the verb nodes share a syntactic node specifying how they can be combined with other words in the sentence; however they have different links with the syntactic nodes. So, an explanation of priming based on both the residual activation of nodes and the links between them is consistent with the fact the priming is reduced when the verb differs between prime and target.

When a prime and target are produced in different modalities, the verb nodes for each sentence again map onto the same syntactic nodes; however, because they are produced in different modalities, they will access these nodes via different links. Consequently, it seems reasonable to argue that there would be a reduction in the magnitude of effects for cross-modality priming as compared to within-modality priming. While residual activation of the syntactic nodes should affect subsequent production, residual

activation of the link between the verb node and the syntactic node should not affect subsequent production as the next sentence will be produced in a different modality.

A reduction of this sort was not found within or across the experiments. This is of course arguing on the basis of a null result, and it could be argued that the method was not sensitive enough to reflect a reduction in priming. However, it is worth bearing in mind that the method did show a reduction in the magnitude of priming in the between verb experiment as opposed to the same verb experiment, therefore it is likely that a reduction in the magnitude of priming between modalities would have been detected if it was there.

One possibility is that reading the prime fragment would result in some activation of the verb at the O-lexeme. For example, reading a prime sentence fragment involving the word 'give' might result in activation of the O-lexeme GIVE. If the subject then produced a spoken sentence involving the word 'give', then the link between the combinatorial node and the O-lexeme 'give' could be strengthened. Hence, there may be no reduction in priming effects on a subsequent written target trial. This could account for the lack of a reduction of priming in the case where the target sentence was written and the prime sentence was spoken without postulating shared syntactic nodes. However, as Shelton and Caramazza (1999) postulate separate processes for comprehension and production, this account seems unlikely. In addition, this account does not cover the case where the prime sentence was written and the target spoken.

Presumably the IN model could account for the pattern of results depending on what kind of assumptions were made about the syntactic nodes, and depending on what account Caramazza et al. might offer to account for syntactic priming effects; after all, these conclusions are based on only one interpretation of the IN model. However, what is clear is that the IN model is currently under-specified and is open to a number of interpretations, some of which can be ruled out on the basis of these experiments.

3.8.3 Modality neutral lemma model

The modality neutral lemma model postulates that semantic representations are linked to a lemma level which specifies syntactic but not word-form information, which is in turn linked to modality specific word-form representations (e.g. Levelt et al., 1999). Hence, in this account, syntactic information is accessed in the same way regardless of whether the final output is written or spoken. The locus of syntactic priming in this model is the lemma level, where residual activation of previously activated information results in the reuse of syntactic structures (e.g. Pickering & Branigan, 1998). As the lemma level is accessed in the same way for orthography and phonology, the prediction based on this model would be that syntactic priming would occur regardless of whether the prime and target sentences were in the same or different modalities. Therefore, the results of Expts. 3, 4 and 5 are entirely consistent with the modality neutral lemma model.

3.8.4 The effect of the modality of the target

It is interesting that while the modality of the prime had no effect on the overall magnitude of syntactic priming, the modality of the target did have a marginal impact. The magnitude of priming was reduced from 34% when the target was spoken, to 17% when the target was written. In addition, significantly more Others were produced when the target was written than when it was spoken. This suggests that the modality of the target does have an effect on syntactic priming. While Hartsuiker and Westenberg (2000) found that priming in written language was equivalent to priming in spoken language, there is some evidence that syntactic priming in written production decays more rapidly than in spoken production. While Branigan et al. (1999) found only marginal syntactic priming effects with as little as one intervening item between prime and target, Branigan, Pickering, Stewart & McLean (2000) found that spoken priming was undiminished over one intervening trial. Bock and Griffin (2000) found an even longer lasting effect of spoken priming, with effects persisting over as many as ten trials. It may be that this is due to the fact that written production is a more costly or lengthy process than spoken production.

The current results suggest that these differences were due to differences between written and spoken targets rather than written and spoken primes.

This interpretation of the data is based on an account of priming where residual activation of nodes and the links between them results in repetition of certain structures, and, to be fair, this is not the only account of priming. However, the principle finding, that is, that the modality of the prime and target sentences does not affect the magnitude of the priming effect, as broadly similar implications for any account of production. In other words, the processes behind choice of syntactic structure are broadly the same for both written and spoken production.

3.9 Conclusion – are syntactic representations shared between spoken and written production?

The aim of this chapter was to investigate whether syntactic representations are shared between spoken and written production. Given that syntactic priming occurred regardless of whether primes and targets were produced in the same or different modalities, it appears that syntax is accessed in much the same way for both processes. Written language is somewhat neglected in research on language production, with research often limited to only the higher processes involved in writing (e.g. Hayes & Flower, 1986); however the results of this chapter suggest that any complete model of language production must account for the fact that syntactic information is accessed in the same way for spoken and written production. Models which postulate that syntactic information is represented separately for orthography and phonology are clearly inadequate to account for the results described here. Models which postulate that syntactic information is shared but accessed separately for orthography and phonology, such as the IN model, need to provide a fuller account of how the processes behind this would operate. The modality neutral lemma model (e.g. Levelt et al., 1999) which assumes that syntactic information is represented as intervening between, but separate from, semantic representations and modality specific word-form representations is the most consistent with the results presented here. In any case, while writing may involve different conceptual processes to speaking, and certainly involves different articulatory processes, the formulation process itself overlaps considerably between the two.

3.10 Summary

To summarise, three experiments examined whether the magnitude of syntactic priming was affected by whether prime and target sentences were produced in the same or different modalities. This was motivated by the need for models of language production to specify whether syntactic information is accessed in the same way for spoken and written production. Across all experiments, the modality of the prime did not affect the magnitude of syntactic priming; the same effects occurred whether the prime and target were produced in the same or different modalities. This suggests that syntactic information is accessed in the same way for spoken and written production.

Chapter 4

Semantic and phonological influences on syntactic encoding:

Evidence from repetition of noun phrase structure

4.0 Overview

This chapter investigates semantic and phonological influences on syntactic repetition of noun phrase structure between speakers in a dialogue. I will first review some of the literature which deals with repetition in dialogue. Expt. 6 investigated syntactic repetition of noun phrase structure using the confederate priming technique (Branigan, Pickering & Cleland, 2000). It demonstrated that the structure of speakers' utterances were significantly influenced by the structure of their dialogue partner's immediately preceding utterance, and that lexical overlap between prime and target enhanced this effect. This is interpreted in terms of representation of syntactic information for nouns at the lemma level. Expt. 7 found that semantic overlap between prime and target enhanced this effect, while Expt. 8 found that phonological overlap between prime and target did not influence this effect. The interpretation of these results is two-fold. In the first instance, the results are interpreted in terms of a model of language production where syntactic information is shared between production and comprehension. Additionally, they support a model where multiple lexical representations receive activation from the semantic level but activation does not feed back from the word-form level of representation (e.g. Levelt et al., 1999).

4.1 Introduction: Repetition in Dialogue

The second two experiments in this chapter are principally concerned with the impact of semantic and phonological similarity on the magnitude of syntactic priming, and hence the role of semantics and phonology in models of language production is crucial. However, the method used to investigate these effects is essentially a dialogue task. Chapter 1 provides a review of the major models of language production, but it does not provide a review of dialogue research. The introduction to this chapter therefore addresses this issue, with an emphasis on repetition in dialogue and how different forms of

repetition may inform us about the mechanisms and representations underlying production and comprehension.

Repetition in dialogue operates at a number of levels. Early research on convergence in speech centred around speech accommodation theories, which were based on observations that a person's speech characteristics could have an effect on the way in which he or she was perceived and evaluated by others. For example, d'Anglejan and Tucker (1973) found that Canadian-style French speakers perceived European-style French speakers as more intelligent, ambitious and likeable but less tough than speakers of their own accent. Similarity-attraction theory holds that an individual can induce another to evaluate him more favourably by reducing dissimilarities between himself and the other person (Giles and Powesland, 1975). According to speech accommodation theory, speakers express themselves in a similar manner to their conversational partner so that they will be viewed more favourably. There is some empirical evidence to support this stance. For example, Mehrabian (1971) found that subjects highest on a measure of affiliative needs showed the greatest tendency to reciprocate positive verbal and non-verbal signals provided by their dialogue partners. Dabbs (1969) found that a person who appeared to match the gestures and postures of the person with whom he was interacting was more liked than someone who did not. Theories of attribution have also been incorporated into models of speech accommodation (e.g. Simard, Taylor & Giles, 1976; see Giles & Powesland, 1975 for a review); our evaluations appear to be affected by our perception of the ability of the speaker to accommodate their speech to us, the effort exerted by the speakers, and external factors such as uncertainty of a partner's motives.

'Response matching' was a term introduced by Argyle (1969) to refer to the fact that in social interaction it is very common for an act on the part of one participant to be followed by a similar act from another. Argyle suggested that speakers could match their conversational partners on factors such as length of utterances, interruptions and silences, kind of utterance (e.g. jokes lead to more jokes), words used, gesture and posture, information about themselves and some other areas such as emotional state. A number of studies have found that speakers match speech rate; for example, Webb (1970) showed that speakers matched speech rate even when questions were presented from a tape. Other response matching effects have been shown in precision and articulation of loudness (Giles & Powesland, 1975), the

frequency of interruptions (Argyle & Kendon, 1967) and the frequency of pauses in speech (Jaffe & Feldstein, 1970). Research in dialogue situations has demonstrated that pairs of speakers display more response matching each time the pair meet (Lennard & Bernstein, 1970; Welkowitz & Feldstein, 1970; Garrod & Doherty, 1994).

Current accounts of convergence in dialogue view conversation as a collaborative process (Clark & Wilkes-Gibbs, 1986; Schober & Clark, 1989; Garrod & Doherty, 1994; Brennan & Clark, 1996). Early research by Krauss et al. (Krauss & Weinheimer, 1964; 1966; 1967; Krauss & Bricker, 1966) used a dialogue task which involved speakers describing abstract shapes to one another. These studies found that speakers' descriptions dramatically reduced in length as the task processed. More importantly, this reduction appeared to be dependent on listener feedback; if feedback was disrupted or delayed, the amount of abbreviation was reduced. Krauss et al. suggested that coordination between communicators was critical for referential processes.

Clark & Wilkes-Gibbs (1986) developed a dialogue task involving tangram figures (abstract geometrical shapes). Pairs of speakers were asked to describe tangram figures to one another and to match pictures with their interlocutor's descriptions. Similarly to Krauss et al., they found that speakers developed abbreviated ways of referring to the figures. Clark and Wilkes-Gibbs noted that the references seemed to be built up by both of the participants in the task, and proposed the principle of *least collaborative effort*: whereas earlier models suggested that speakers worked alone to produce the minimum information necessary for their partner to understand (e.g. Olson, 1970), Clark and Wilkes-Gibbs suggested that both the speaker and the addressee worked together to minimise the effort involved in conversation. Together, pairs of speakers established ways of referring to objects so that they both understood what was being referred to, and so minimised the effort involved in their conversation. However, this was not through specific negotiation, rather through the feedback that the speakers gave each other. In addition, it appears that speakers can take into account their addressees to a quite sophisticated level, in that they are aware of how much or how little information their conversational partner has access to and can modify their speech accordingly (eg. Clark & Schaefer, 1987).

Schober and Clark (1989) provided strong evidence for a view of conversation as a collaborative process. They observed that, according to an autonomous view, an overhearer to a conversation between two people should not be at a disadvantage, as long as all three were from the same culture, did not know each other, and the overhearer was listening to the entire conversation. However, according to a collaborative view, overhearers should be at a disadvantage because they cannot take part in the collaborative, grounding processes: that is, they are unable to take part in establishing that they have an understanding with the speaker, as they do not interact with the speaker. Schober and Clark found that an overhearer was at a disadvantage when trying to match cards as part of the tangram task but without taking part in the conversation itself. This disadvantage persisted even in the case where they were given a audio recording of the game which they could stop and start as they wanted. Schober and Clark argued that these findings were incompatible with an autonomous view of conversation given that the overhearer has access to the same information as the other participants. Instead, it appears that taking part in a conversation is fundamentally different to listening to others' conversations without taking part. Schober and Clark proposed the theory of grounding which involves building a shared perspective between interlocutors through collaboration.

Brennan and Clark (1996) investigated the mechanisms behind 'lexical entrainment', that is, the tendency for dialogue pairs to refer to the same object repeatedly using the same term (for example, referring to a shoe as a 'loafer'). Brennan and Clark distinguished between ahistorical and historical accounts of lexical entrainment. An ahistorical account might postulate that speakers choose to reuse a referring term because it seems the most salient at the time, regardless of the shared experience of the speakers involved. An historical account would take into account specifically how the current conversational partner had so far conceptualised the object, based on the pair's previous interactions, as well as the recency and frequency of past references. The results supported an historical account; speakers showed a sensitivity to their addressee, so they would continue to use referring expressions with a partner which were in fact overly specific given the context. However, if the same speaker then had to speak to a new partner, they quickly accommodated to the fact that the new addressee did not have a shared history with them. Brennan and Clark concluded that speakers in a dialogue form conceptual pacts over the course

of a conversation, that is a temporary agreement on how to refer to and conceptualise an object. According to this account, repetition of referring expressions in a conversation is the result of a shared history. However, these pacts are not negotiated explicitly - rather the agreement is implicit. They are established jointly between speakers and addressees and are therefore available to both as they build a common ground through the conversation. In this account, the repetition of referring expressions is the result of an implicit collaboration between speakers. This stands in contrast to an account of repetition based on speech accommodation theory. According to speech accommodation theory, a speaker would choose to use the same referential terms as their addressee because they wanted to express themselves in a similar way, so that the addressee might take a more favourable view of the them (although the speaker would not necessarily be aware they were doing this).

Garrod and Anderson (1987) investigated convergence in a situation where speakers had to be able to communicate effectively in an ambiguous situation. Participants in a dialogue played a maze task which involved describing their position in a maze to one another when they both had differing and incomplete information about the maze. There were various ways of managing this; for example, subjects could use a 'path scheme' description where they described their positions in terms of following directions along the maze, or they might use a 'matrix scheme', breaking the maze into horizontal and vertical lines on a grid. Garrod and Anderson found that the dialogue pairs tended to converge on one description scheme by the time they had played one game. Importantly, there was very little explicit negotiation leading to this; in fact, even when explicit negotiation occurred, it was a poor predictor of subsequent descriptions. Garrod and Anderson proposed the principle of 'output/input coordination': the speakers formulated their output so that it conformed to the same rules of interpretation as the rules needed to understand the last input.

In a variation of this task, Garrod and Doherty (1994) varied the relationships between the pairs of speakers. So, in one condition speakers changed partners regularly, but the pairs of speakers were always drawn from the same group of people. In other words, although they were not aware of it, the dialogue pairs in this condition formed a community in that they all played the maze task with one another. Garrod and Doherty found that when pairs of speakers were drawn from this 'community',

convergence still occurred, even though the pairs of speakers changed regularly. In fact this condition yielded a stronger degree of convergence than other conditions where pairs of speakers played the game repeatedly or where speakers changed regularly but were not from the same 'community'. In short, the strategy of coordinating referring expressions appeared to be of benefit to the dialogue pairs, and increased the chance that the other participant would understand the speaker's meaning (see also Garrod & Clark, 1993)

There is a large body of literature which is concerned with how speakers build common ground, and to what extent they are capable of taking their addressee's experience into account during language production (e.g. Fussell & Krauss, 1989; Horton & Keysar, 1998; see Keysar, Barr & Horton, 1998 for a review). Much of this research is predominantly concerned with the degree to which speakers are sensitive to the knowledge state of their addressees. However, for the purposes of this chapter, the important point is that repetition appears to be an intrinsic part of dialogue, for example in the lexical expressions used to refer to an object or an abstract scheme used to conceptualise a situation.

4.1.1 Syntactic repetition in dialogue

There is evidence that this convergence between speakers occurs at the syntactic level as well as at the conceptual and lexical levels (Schenkein, 1980; Tannen, 1989; Levelt and Kelter, 1982; see Chapter 1 for a review). While the apparent repetition of syntactic structure in these studies might be attributed to lexical repetition, or discourse factors such as register, Branigan, Pickering & Cleland (2000) provided evidence that syntactic repetition occurred in a dialogue and was unlikely to be due to non-syntactic effects.

The series of experiments presented in this chapter made use of the confederate priming technique developed by Branigan et al., and which allows a degree of control over the type of utterance produced by the participant. Pairs of speakers took part in a dialogue task which involved taking it in turns to describe cards to their partner, and then to match a card to their partner's next description; so, each participant had a set of cards which they described to their partner, and a set of cards from which they matched cards to their partner's description. The cards depicted simple distransitive scenes, and had a verb

written on them which the speakers were asked to use in their descriptions. One of the participants was in fact a confederate of the experimenter and was scripted to produce their descriptions using certain structures. Branigan et al. controlled whether some of the confederate's descriptions were of the PO or DO form. They investigated whether the experimental participant's subsequent description of a cards depicting a ditransitive scene was influenced by the immediately preceding prime description. This technique allows a degree of control over the type of utterance produced by participants in a dialogue, as the confederate can be scripted to produce utterances using particular syntactic structures. In addition, the content of both the confederate and the experimental subject's descriptions was limited by the objects depicted on the card.

Branigan et al. found that the structure of the experimental subject's target description was highly influenced by the structure of the confederate's immediately preceding prime description, so if they had just heard the confederate produce a PO description, the subject was very likely to produce a PO description on their next trial, and if they had just heard the confederate produce a DO description they would be likely to produce another DO structure. Branigan et al. argued that the effects supported the hypothesis of shared syntactic representations underlying comprehension and production that are activated during spontaneous dialogue (e.g. consistent with Levelt et al., 1999). According to an account based on Pickering and Branigan (1998), residual activation of combinatorial nodes specifying how a verb can be combined with other elements in a sentence, and the links between these nodes and the verb was the source of the priming effect.

4.2 Syntactic priming of noun phrase structure

This series of experiments investigates the repetition of noun phrase structure using the confederate priming technique. As reviewed in chapter 1, it has already been shown that ditransitive and active and passive structures show syntactic priming effects (e.g. Bock, 1986b; Bock & Loebell, 1990; Pickering & Branigan, 1998). In addition, Hartsuiker et al. (1999) found locative inversion repetition, and Hartsuiker and Westenberg (2000) found priming of verb-auxiliary order. Smith and Wheeldon (2001) found priming effects for coordinate noun phrase structure (e.g. 'The eye and the fish move apart' versus

‘The eye moves up and the fish moves down’). The experiments investigated the repetition of structure within a single noun phrase. Given an object to describe such as a red square, a speaker may choose to combine the noun with a pre-nominal adjective, as in ‘the red square’ (henceforth, Adj-first structure), or with a post-nominal phrase containing the adjective, as in ‘the square that’s red’ (henceforth, Adj-last structure). The following experiments made use of the confederate priming technique to investigate whether the speakers’ choice of syntactic structure was influenced by an immediately preceding prime description.

It is generally assumed that syntactic information is represented for nouns at the lemma level, just as it is for verbs. For example, in an account of the lemma stratum proposed by Roelofs (1992), the Dutch noun *hond* (dog) is represented at the syntactic stratum with links to nodes specifying that it is a noun, and has non-neuter grammatical gender. Evidence to support this account arises from, for example, TOT effects (e.g. Vigliocco et al., 1997; 1999; Badecker, 1995). So for example, speakers in a TOT state can have access to grammatical gender or count and mass information without necessarily being able to produce a word’s phonological form (see chapter 1 for a review). Evidence from syntactic priming studies has been cited to suggest that combinatorial information is also somehow specified at the lemma level, so Pickering and Branigan argued that information specifying how a verb may be combined with other elements in a sentence was represented in the form of combinatorial nodes.

Experiment Six investigated the issue of whether people were likely to reuse noun phrase structure. The confederate priming technique was modified so that instead of describing pictures of simple scenes, participants described coloured objects to one another. The confederate produced scripted descriptions, with either an Adj-first or an Adj-last structure. Of interest was whether the structure of the subject’s description was influenced by the structure of the confederate’s immediately preceding prime description. In addition, the degree of lexical overlap between prime and target was manipulated to assess what effect this might have on the magnitude of the repetition effect.

4.3 Experiment Six

4.3.1 Method

4.3.1.1 Participants

Sixteen students from the University of Edinburgh community were paid to participate.

4.3.1.2 Items

Four sets of cards were prepared. Each set of cards contained 15 different shapes, which could each appear in 10 different colours. The shapes were simple and easy to recognise (*arrow, bar, circle, club, cross, diamond, heart, moon, oval, ring, spade, square, star, sun and triangle*) and the colours were *black, blue, brown, green, grey, orange, pink, purple, red and yellow*. The confederate and the subject each had two sets of cards; one was the set of cards which they would describe to their partner, and the other was the set of cards from which they would match cards to their partner's descriptions.

Forty-eight experimental items were constructed (see Appendix). These consisted of a scripted description of one of the cards which would be produced by the confederate, and a target card which the subject would describe on the next trial: e.g.

- 1a. The red square
- 1b. The square that's red
- 1c. The red diamond
- 1d. The diamond that's red
- 1e. The green square
- 1f. The square that's green
- 1g. The green diamond
- 1h. The diamond that's green
- 2. RED SQUARE

So, an experimental item was defined as the confederate's scripted description of a prime card (1a-1h) plus the target card which the subject would subsequently describe (2). The prime fragments were simple noun descriptions which the confederate described using 2 different syntactic structures. The first structure took the form of a noun preceded by a pre-nominal adjective (the Adj-first structure). The second took the form of a noun with a post-nominal modifier (the Adj-last structure).

The degree of lexical overlap between the prime and target descriptions was also manipulated, so the noun could be repeated or different between prime and target, and the adjective could be repeated or different between prime and target. Hence, there were eight possible conditions for each experimental item:

Adj-first prime x same adjective x same noun
 Adj-last prime x same adjective x same noun
 Adj-first prime x same adjective x different noun
 Adj-last prime x same adjective x different noun
 Adj-first prime x different adjective x same noun
 Adj-last prime x different adjective x same noun
 Adj-first prime x different adjective x different noun
 Adj-last prime x different adjective x different noun

Eight lists of items were constructed, such that each list contained six items in each condition, and one version of each item. Each list also contained 48 filler pairs. Each filler pair consisted of a scripted confederate description, and the subsequent card that the subject would describe. Within each pair, the confederate and subject's cards contained different nouns and adjectives from each other. The filler trials intervened between each experimental trial, and were included to make the experimental trials less obvious. As the task involved describing coloured shapes, the confederate's description on filler trials had to have either the Adj-first or Adj-last structure, and this meant that they had the same structures as the prime descriptions. Eighteen of the confederate's filler description were assigned the Adj-first structure, and 18 were assigned the Adj-last structure. While having filler trials of the same structure as the prime trials may have affected the magnitude of priming on any given trial, the fact that they were split

evenly and were randomised in order meant that any influence they did have could be treated as random noise. The lists were individually randomised with the constraint that one filler pair intervened between any two experimental trials.

The cards which the participants would describe were ordered so that they matched the order of each list, and a script was generated for the confederate which specified which prime and filler descriptions they were to produce on each trial.

4.3.1.3 Procedure

Fig. 16 shows a diagram of the experimental set up for Expts. 6,7, and 8. The participants were seated on either side of a table, with a wooden screen between them so that they could not see the other person's cards. Each participant had a box which contained a set of cards to describe, and a set of cards laid out on the table that they would choose from. The set of cards to choose from were arranged into groups of each shape. The cards were laid out in a 15x10 grid (length by width). The different shapes were laid out in 10x2 groups. There were therefore a total of 150 cards in front of each subject. Each participant also had an empty box into which they would put the cards that they matched to their partner's descriptions.

The cards in the boxes were ordered according to the experimental lists so that the prime and target description were always adjacent. In addition, the confederate of the experimenter had a script on the table in front of them which specified the syntactic structure they were to produce for each description

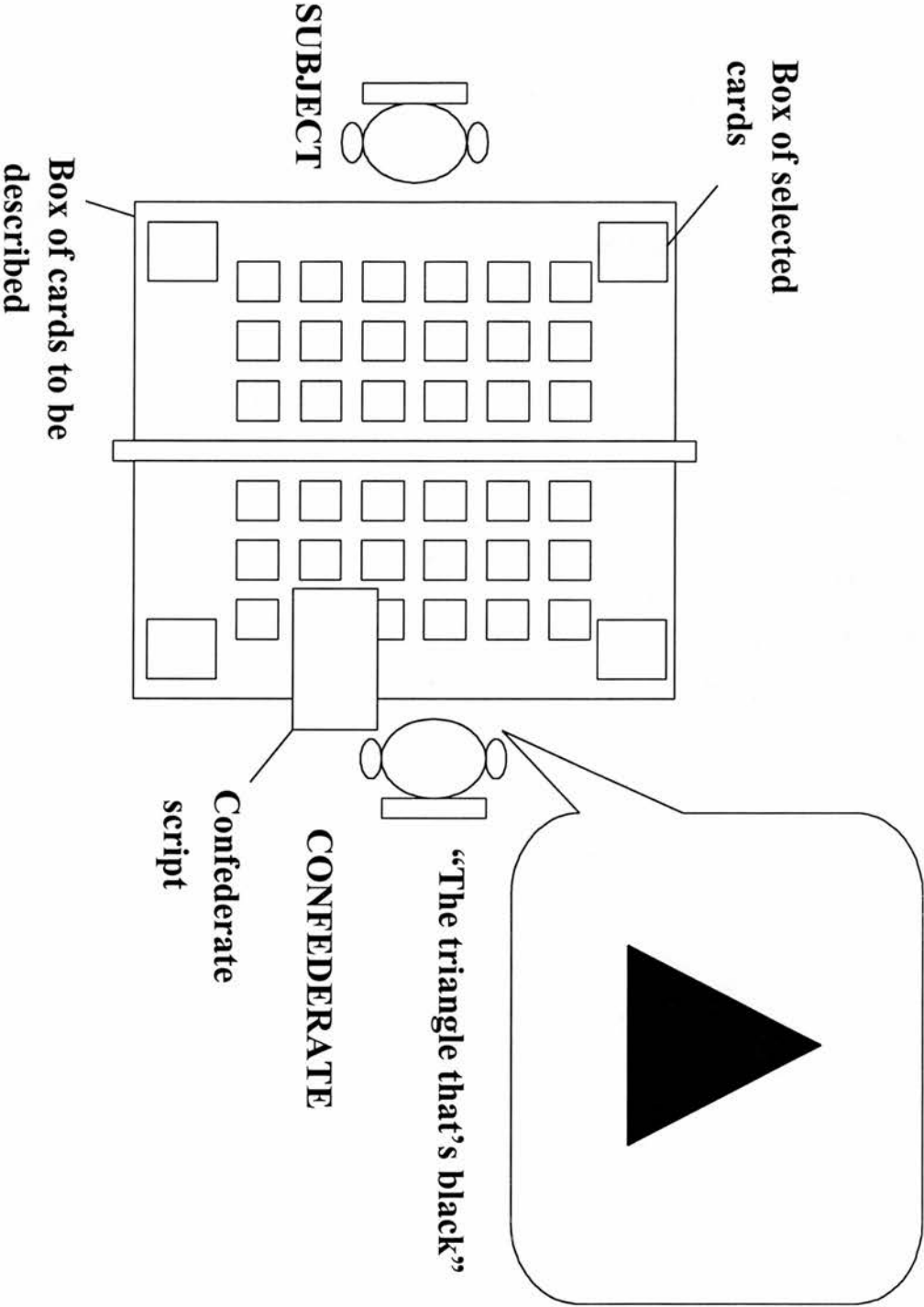


Fig 16: Confederate Priming Technique

In a set of written instructions, the subject and confederate were told that the experiment was concerned with how well people communicate when they cannot see each other, and that the participant's goal was to end up with a set of cards in the same order as their partner's. They therefore had 2 tasks: the first was to describe the cards in the box in front of them to the other person who would then match cards to their description; the second was to listen carefully to their partner's descriptions and pick out the card from the table in front of them which matched the description, and place it in the empty box. They were instructed that they could say 'Please repeat' if they wished to hear a description again, but that they should not say anything else. There was no practice session, but participants were given a chance to ask about anything they did not understand before the experimental session began. The experimenter and the confederate behaved as if the confederate was a genuine participant throughout the course of the experimental session.

The experimental session was recorded onto audiotape and subsequently transcribed. The session lasted about half an hour.

4.3.1.4 Scoring

The participants' descriptions were transcribed from the tape recordings and each was scored as Adj-first, Adj-last or Other. An Adj-first structure was defined as an utterance where the adjective preceded the noun (e.g. 'red square', 'the red square', 'a red square'). An Adj-last structure was defined as an utterance where the noun was followed by a post-nominal phrase containing the adjective (e.g. 'square that's red', 'the square that's red', 'square that is red', 'the square that is red', 'the square which is red', 'square which is red'). The vast majority of Adj-last descriptions included that word 'that', with less than 1% of these utterances containing the word 'which'. Utterances scored as either Adj-first or Adj-last had to consist of a grammatical noun phrase or a grammatical noun phrase minus a determiner. All other utterances were scored as Other. For example, descriptions of the type 'square red' were scored as Other because they did not constitute a grammatical utterance.

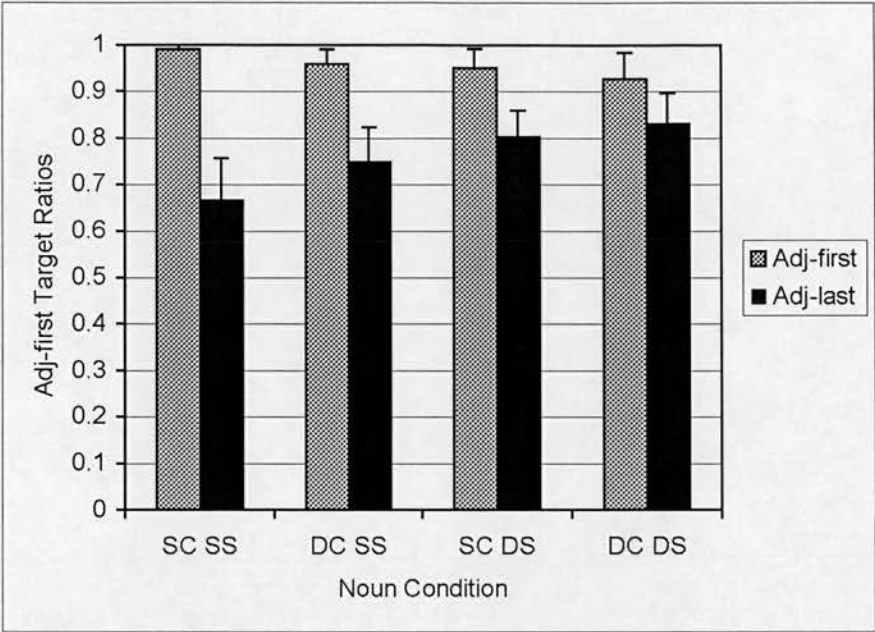
4.3.1.5 Design and Data Analysis

Every participant produced 48 target utterances, six in each of the eight priming conditions defined by the two levels of the Prime Construction factor (Adj-first vs. Adj-last), two levels of the Adjective factor (Same vs. Different), and two levels of the Noun factor (Same vs. Different). Every experimental item was described by all 16 participants, with two participants seeing any one version of an item.

Other responses accounted for four utterances, 0.5% of the total target responses. A measure was computed which was designed to determine the relative proportions of Adj-first and Adj-last target responses in each of the priming conditions. This measure (Adj-first Target Ratio) was the proportion of Adj-first responses divided by the sum of the proportion of Adj-first responses and the proportion of Adj-last target responses. Despite the low numbers of Others produced, this measure was employed because it allowed the comparison of priming between conditions in cases when the proportions of Other responses was not equivalent. Analyses of variance were performed on the data, with separate analyses treating participants (F1) and items (F2) as random effects. The analyses were within-participants and within-items. These measures were consistent with previous experiments investigating syntactic priming of ditransitive structures.

4.3.2 Results

Fig. 17 reports the Adj-Target Ratios across the different conditions. ANOVAs on the Adj-first Target Ratio revealed an effect of Prime Construction ($F(1,15)=18.15$, $p<.005$, $MSe=.066$; $F(1,47)=41.95$, $p<.001$, $MSe=.11$). So, there was a 19% priming effect across the experiment (so, 19% more target utterances were of the same structure as the prime description than were of the alternative structure). In addition, there was a significant interaction of Noun Condition by Prime Construction ($F(1,15)=5.32$, $p<.05$, $MSe=.031$; $F(1,47)=9.99$, $p<.005$, $MSe=.052$). When the noun was the same



SC SS: Same colour, same shape; DC SS: Different colour, same shape; SC DS: Same colour, different shape; DC DS: Different colour, different shape

Fig. 17. Adj-first Target Ratios across Expt. 6

between prime and target, the magnitude of priming was 27%, and when it was different, the magnitude of priming was 13%. There was a marginal interaction of Adjective Condition by Prime Construction, significant across items only ($F(1,15)=2.08$, $p=.17$, $MSe=.055$; $F(1,47)=4.66$, $p<.05$, $MSe=.028$), with an increased magnitude of priming when the colour remained the same between prime and target (24%) versus the case where it differed (13%).

4.3.3 Discussion

Expt. 6 demonstrated that speakers were significantly more likely to produce a target utterance with the same structure as the confederate’s immediately preceding prime description than with the alternative structure; they produced 19% more utterances of the same construction as the prime description

than of the alternative. This is consistent with the finding of Branigan, Pickering & Cleland (2000) that speakers are likely to reuse syntactic structure in a dialogue setting, and extends the finding to include structure at the level of the noun phrase as well as that at a clausal level. This repetition effect was greater when the noun was repeated between prime and target (27% priming when it was repeated versus 12% when it differed), and there was a tendency for the repetition effect to be greater when the adjective was repeated between prime and target, although this was not statistically significant by the subjects analysis (24% priming when the adjective was repeated versus 13% when it differed). This effect of lexical repetition is similar to the finding of Branigan et al. that syntactic repetition was increased when the verb was repeated between prime and target compared to the case when it differed between prime and target.

It is unlikely that the repetition effect was due to the repetition of the word 'that' or 'is' between prime and target descriptions. Previous work has suggested that syntactic repetition in other settings is not due to lexical repetition (e.g. Bock, 1989). In addition, while repetition of 'that' or 'is' may be sufficient to account for an overall repetition effect, it does not offer an explanation for the finding that the priming effect was greater when the noun was repeated between prime and target than when it was different. While 'The square that's red' might appear to be a more unusual choice of form than 'The red square', subjects did not seem to have any difficulties with that form of the sentence. One concern was that the previous structure was not well-formed, or uncommon enough that subjects would not tend to use it; however this did not appear to be the case.

Instead, it appears that noun phrase structure is subject to the same kind of repetition effects as clausal structures. These results are consistent with an account of language where lemma representations are shared between comprehension and production mechanisms (e.g. Levelt et al., 1999; Branigan et al., 2000). They are also consistent with the hypothesis that priming is due to the residual activation of representations at the lemma level, rather than due to the residual activation of procedures associated with production (a possibility discussed by Bock & Loebell, 1990). This is because representations may be shared between comprehension and production, but it is less likely that procedures should be (cf. Branigan, Pickering & Cleland, 2000 for a similar argument).

Branigan et al. proposed an account of syntactic repetition in dialogue where verb nodes at the lemma level were linked to combinatorial nodes specifying how the verb might be combined with other words in the sentence. So, one node might specify a prepositional object structure (NP,PP node), and another the double object structure (NP,NP node). Residual activation of these nodes, and the links between them was proposed as the source of the priming effect for ditransitive structures.

The results of Expt. 6 suggest that a similar account could be proposed for nouns. So, at the lemma level there may be some form of representation which specifies rules for how the nouns can be combined with other elements within the noun phrase. These might broadly correspond to the Adj-first and Adj-last structures produced during the experiment. Having heard a description of one type, this information would become activated, and so on a subsequent utterance the residual activation of this information would be likely to result in a speaker reusing that syntactic structure. The repetition effects were enhanced when the noun was repeated between prime and target. This is consistent with the Pickering and Branigan (1998) account where priming is due to the links between nodes as well as the nodes themselves. So when one structure is used, a combinatorial node specifying the rules to produce that structure becomes activated, as well as the link between the noun node and the combinatorial node. If the same noun is repeated on a subsequent utterance, the combinatorial node will be activated, and the link between it and the noun node, and so the speaker will be likely to reuse that syntactic structure. This contrasts with the case where the noun is different in the target. In this case, activation of the combinatorial node is still likely to result in the reuse of the corresponding structure, but there is no additional effect of the link between the noun node and the combinatorial node.

4.4 Semantics and the lemma level

Expt. 7 investigated that degree to which semantic factors influenced the syntactic repetition effect. Currently a model of the lemma level such as Pickering and Branigan (1998) does not take into account how the conceptual stratum might influence syntactic structure; Expt. 7 was designed to investigate whether the influence of the conceptual stratum might need to be taken into consideration in an account of syntactic repetition. According, to the Levelt et al. (1999) account, multiple lemmas receive

differing degrees of activation from the conceptual level, and are selected on the basis of their degree of activation relative to other lemmas. At the conceptual level, lexical concepts are activated together through spread of activation. So, if the conceptual node for *goat* were selected, this would result in a degree of activation of semantically related conceptual nodes such as *sheep*, due to spreading activation at the conceptual level. These lexical concepts then spread activation to their corresponding lemma nodes; so, the lemma GOAT will become highly activated. However, the lemma node for SHEEP will also receive a degree of activation from the conceptual level. A lemma for an unrelated concept, such as DOOR will have a lower level of activation than SHEEP, which in turn will have a lower activation than GOAT.

Expt. 6 demonstrated that a prime description such as ‘the sheep that’s red’ is more likely to lead to a subsequent target description of the same structure when the noun is repeated (i.e. ‘the sheep that’s red’) than a prime description such as ‘the door that’s red’ where the noun is different from the target description. This is consistent with an account where noun nodes are linked to information specifying how they might be combined with other elements within a noun phrase. For the sake of argument, I will refer to these as ‘Adj-first’ and ‘Adj-last’ nodes corresponding to the Adj-first and Adj-last structures, without speculating on the exact nature of how these nodes might operate or represent combinatorial information. This naming is fairly arbitrary, and I would not argue that it therefore follows that there would be a node representing every possible word combination. For example, they might be better envisioned as one node representing a simple noun phrase of the form ‘noun preceded by determiner and/or adjective(s)’ and ‘noun followed by relative clause’. For the sake of simplicity, however, I will stick to ‘Adj-first’ and ‘Adj-last’ for the remainder of the thesis. So, residual activation of these nodes will result in the reuse of the syntactic structure associated with each. The finding that this repetition effect was enhanced by lexical overlap suggests that residual activation of the link between the noun node and the combinatorial node must also contribute to the repetition effect. If the noun is repeated between prime and target, residual activation of both the combinatorial node and the link between the noun node and the combinatorial node will contribute to the repetition effect, and if the noun is different then only the combinatorial node will contribute to the repetition effect.

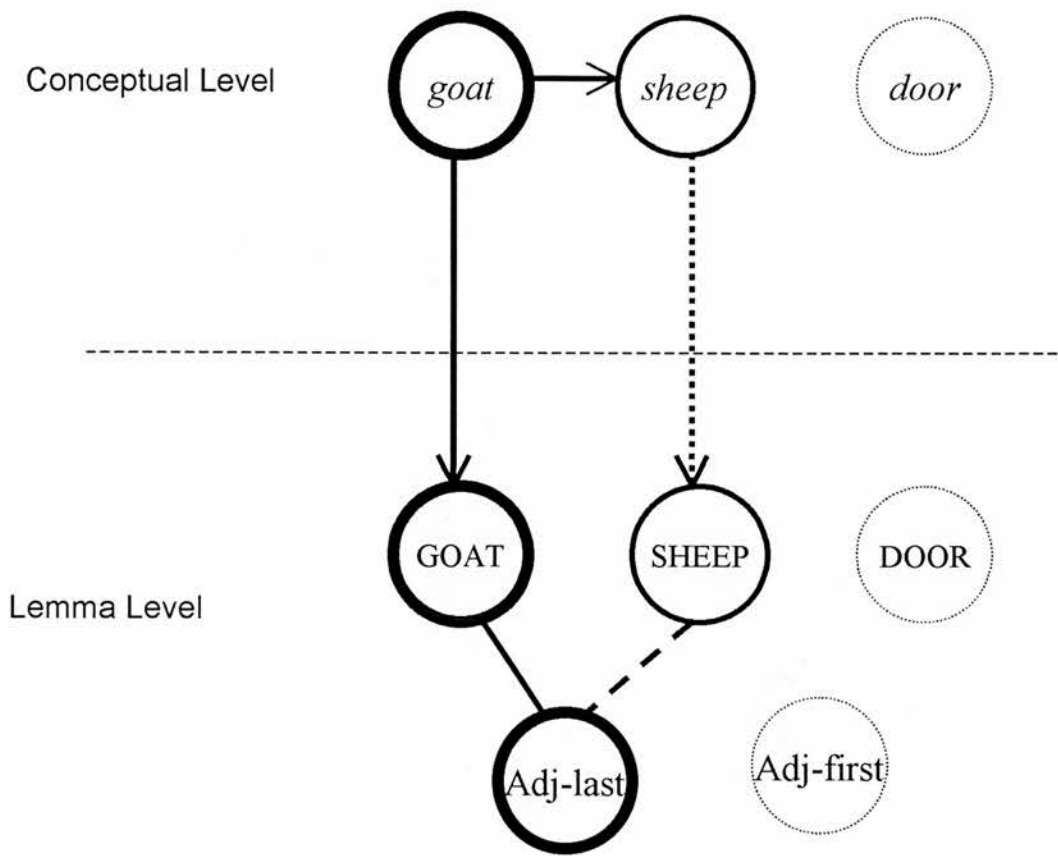


Fig. 18. The patterns of activation following a prime such as 'The goat that's red'

However, it is possible that the account must be expanded to account for repetition in the case where the prime description contains a semantically related noun to the target; for example as in the case of a prime like 'the goat that's red' followed by a target description of a red sheep. As the word 'goat' is semantically related to 'sheep' activation of the conceptual node for *goat* will result in a degree of activation at the conceptual node for *sheep*. As previously argued, both of these nodes will feed activation to their corresponding lemma nodes; the lemma GOAT will become activated, and also to some degree the lemma SHEEP (see Fig. 18 for a simplified representation). As the prime was of the Adj-last structure, the Adj-last node will also become activated, and the link between the Adj-last and the GOAT node. As both the Adj-last node and the SHEEP node are activated, this may lead to some strengthening of the link between them as well, although not to the same extent as between the Adj-last and GOAT nodes.

However, the link between the lemma SHEEP and the Adj-last node will be strengthened relative to an unrelated lemma, such as DOOR. So, on a subsequent trial involving a description of a red sheep, the speaker may be more likely to reuse the Adj-last syntactic structure than in the unrelated case (e.g. description of a red door), as the link between the SHEEP and the Adj-last node is strengthened relative to the unrelated case.

Expt. 7 investigated this issue by manipulating whether the prime description contained a same, semantically related or different noun from the target description, and examined the influence of these different conditions on the magnitude of the syntactic repetition effect. If the repetition effect was increased when the prime and target contained semantically related nouns, then this would imply that the account proposed by Pickering and Branigan (1998) and Branigan et al. (2000) might need to be expanded as outlined above to take into account semantic influences on syntactic encoding. Alternatively, if the semantically related condition did not influence the magnitude of the repetition effect, then this would suggest that the repetition effect was solely due to syntactic factors and unaffected by conceptual factors.

While the items in Expt. 6 consisted of abstract shapes, the items in Expt. 7 included everyday objects, both animate and inanimate. As a result, it might be argued that there is a problem with the fact that some of the items did not make semantic sense (e.g. “the red goat”). However, it is assumed that while a red goat may not, technically speaking, make semantic sense, the subjects would be perfectly able to cope with the concept of a red goat. Certainly during the course of running the experiments, this did not appear to be a problem.

4.5 Experiment Seven

4.5.1 Method

4.5.1.1 Participants

Eighteen students from the University of Edinburgh community were paid to participate. The data from one further participant was excluded as it transpired that they had realised the purpose of the experiment during the experimental session.

4.5.1.2 Items

Four sets of cards were prepared. Each set of cards contained 50 different objects, which each appeared in three different colours. The objects were chosen so as to be easily recognisable, and could be split into pairs of semantically related objects: *arm, leg, axe, saw, banjo, guitar, bed, cot, beetle, spider, boot, shoe, bowl, plate, bread, cheese, brush, mop, bus, train, bush, tree, cap, hat, cat, dog, clock, watch, cup, glass, dress, skirt, duck, goose, fence, gate, foot, hand, fork, knife, fox, wolf, goat, sheep, lion, tiger, moon, star, shark* and *whale*. To qualify as a semantically related pair, the nouns had to be members of the same category; in picture-word interference studies, words which were only semantically associated with a picture did not produce a semantic interference effect (Lupker, 1979, see Chapter 1 for review). The colours were *red, green* and *pink*. The reason for choosing these particular colours was related to Expt. 8 where phonological relatedness between prime and target was manipulated. As many of the nouns began with the letter 'b', colours which did not start with the letter 'b' were used. The confederate and the subject each had two sets of cards; one was the set of cards which they would describe to their partner, and the other was the set of cards from which they would match cards to their partner's descriptions.

Thirty-six experimental items were constructed (see Appendix). As for Expt. 6, these consisted of a scripted description of one of the cards which was produced by the confederate, and a target card which the subject would describe on the next trial: e.g.

- 1a. The red sheep
- 1b. The sheep that's red
- 1c. The red goat
- 1d. The goat that's red
- 1e. The red knife
- 1f. The knife that's red
- 2. RED SHEEP

So, an experimental item was defined as the confederate's scripted description of a prime card (1a-1f) plus that target card which the subject would subsequently describe (2). As for Expt. 6, the form of the prime description could be Adj-first or Adj-last.

The degree of relatedness between prime and target descriptions was also manipulated, so the noun in the prime description could be the same as the noun in the target description, or it could be semantically related, or it could be different. Hence, there were 6 possible conditions for each experimental item:

- Adj-first structure x same noun
- Adj-last structure x same noun
- Adj-first structure x semantically related noun
- Adj-last structure x semantically related noun
- Adj-first structure x different noun
- Adj-last structure x different noun

Six lists of items were constructed, such that each list contained six items in each condition, and one version of each item. Each list also contained filler pairs, which consisted of a scripted confederate description and the subsequent card that the subject would describe. Within each filler pair, the confederate and subject's cards contained different nouns and adjectives from each other. As for Expt. 6, half of the confederate's filler descriptions were of the Adj-first construction, and half were Adj-last. The lists were individually randomised with the constraint that one filler pair intervened between any two experimental items. In all other respects, the cards were prepared in a similar fashion to Expt. 6 .

4.5.1.3 Procedure

The procedure was essentially the same as for Expt. 6 (see Fig. 17). The cards were arranged by object in sets of three according to colour, and in a 15 x 10 grid. Objects which were semantically related were not laid out next to each other. Instead, the groups of cards were arranged alphabetically across the grid (arm, axe, banjo, bed, beetle, boot, bowl, bread, brush, bus, bush, cap, cat, cheese, clock, cot, cup, dog, dress, duck, fence, foot, fork, fox, gate, glass, goat, goose, guitar, hand, hat, knife, leg, lion, moon, mop, plate, saw, shark, sheep, shoe, skirt, spider, star, tiger, train, tree, watch, whale, wolf). It was felt that ordering the cards in this way might make it easier for subjects to locate the cards they were looking for, and so reduce the time between prime and target utterances. Given the nature of the task, some of the cards were quite similar (e.g. duck and goose). To try and reduce the possibility of errors, the participants were each asked to take a minute to make sure they knew what each object was before the experiment began; the instructions included a list of the object's names. The subject and confederate were each asked to read out the cards in front of them to their partner. If they failed to name the objects correctly, the experimenter pointed out their mistake. In all other aspects, the experimental session was similar to Exp. 6.

4.5.1.4. Scoring

See Expt. 6.

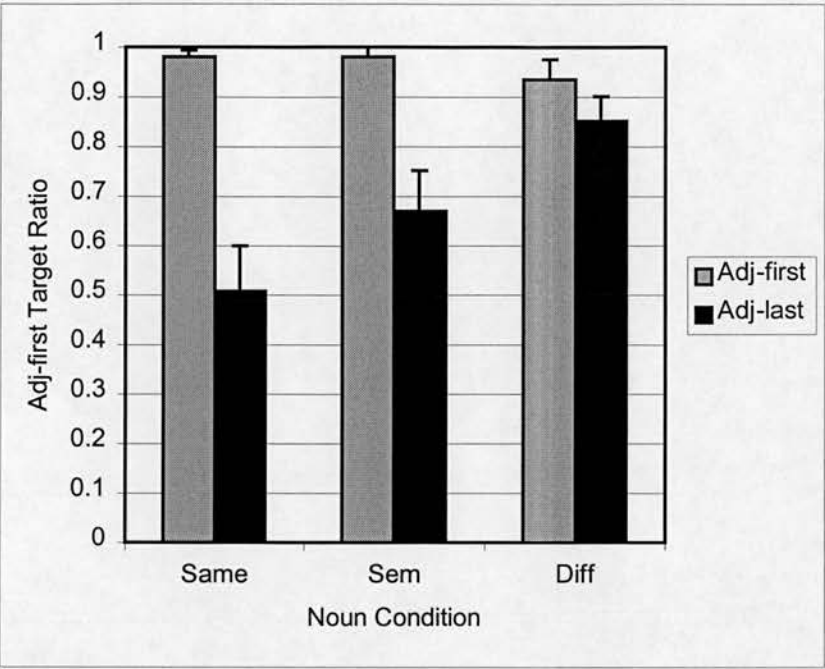
4.5.1.5 Design and Data Analysis

Every participant produced 36 target descriptions, six in each of the six priming conditions defined by the two levels of prime structure (Adj-first vs. Adj-last) and three levels of noun condition (Same vs. Semantically Related vs. Different). Every experimental target was described by all 18 participants, with three participants seeing any one version of an item.

Only one Other response was produced, accounting for 0.2% of the total responses. The Adj-first Target Ratio was calculated as for Expt. 6.

4.5.2 Results

Fig. 19 reports the Adj-first Target Ratios across the different prime conditions. ANOVAs on the Adj-first Target Ratio revealed an effect of Prime Construction ($F(1,17)=26.62$, $p<.001$, $MSe=.085$; $F(1,35)=106.78$, $p<.001$, $MSe=.041$). Across the experiment, 29% more target descriptions were of the same structure as the prime description than were of the alternative. In addition, there was a significant interaction of Prime Construction by Noun Condition ($F(2,16)=11.60$, $p<.005$, $MSe=.031$; $F(2,34)=19.37$, $p<.001$, $MSe=.042$). When the noun remained the same between prime and target, the magnitude of priming was 47%, when the prime noun was semantically related to the target noun there was a 31% priming effect, and when the prime noun was unrelated to the target noun there was a 8% priming effect. Planned comparisons revealed that the priming effect in the Same condition was significantly greater than in the Semantically Related condition, although marginal by subjects ($F(1,17)=3.62$, $p=.074$, $MSe=.032$; $F(1,35)=5.55$, $p<.05$, $MSe=.042$) and that the priming effect in the Semantically Related condition was significantly greater than in the Different condition ($F(1,17)=7.05$, $p<.05$, $MSe=.033$; $F(1,35)=9.50$, $p<.01$, $MSe=.049$).



Same: Same noun between prime and target; Sem: Semantically related noun in prime description; Diff: Different nouns in prime and target

Fig. 19. Adj-first Target Ratios across Expt. 7

4.5.3 Discussion

Expt. 7 again demonstrated that the experimental subjects were significantly more likely to produce a target description with the same structure as the prime description than with the alternative structure; overall, they produced 29% more target descriptions of the same structure as the prime than of the alternative construction. Crucially, the magnitude of priming was increased when the prime description contained a noun semantically related to the noun in the target description compared to the case where the nouns were unrelated (31% priming when the prime was semantically related compared to 8% priming when it was unrelated). As in Expt. 6, the magnitude of priming was significantly greater when the noun was repeated between prime and target than when it was not; and was in fact significantly

greater when the noun was repeated compared to when the noun was semantically related (47% priming when it was repeated versus 31% when it was semantically related).

The finding that semantic relatedness enhanced the syntactic priming effect suggests that semantic factors can have an effect on syntactic processes. This is consistent with the model proposed by Levelt et al. (1999) where multiple lemmas receive activation from the conceptual level. On the basis of the data presented here it is possible to extend the Pickering and Branigan (1998) model of syntactic priming to involve these factors. So, lemmas which are semantically related to the word being produced will become activated to a greater degree than unrelated lemmas, but to a lesser degree than the lemma for the word to be produced. In addition, the fact the lemma and the combinatorial node are activated will lead to a strengthening of the link between the two. So, on a subsequent utterance involving the semantically related word, the speaker will be more likely to reuse the syntactic structure than when producing a sentence involving an unrelated word. This issue will be returned to in the General Discussion.

4.6 Phonology and syntactic encoding

There is some debate in the field of language production as to the degree to which phonology can affect syntactic encoding. In an account such as that proposed by Levelt et al., activation does not feedback from the phonological to the lemma level and so does not affect syntactic encoding. However, proponents of an interactive model of language production (e.g. Dell, 1986; Dell & O'Seaghdha, 1992) have argued that activation does in fact feed back from the phonological to the previous levels (see Chapter 1 for a review).

There is some evidence that phonology can affect choice of word order. Bock (1987) found that words which were rendered less accessible due to a phonological prime were placed later in a sentence. Based on dysfluency analyses, Bock argued that this was not due to feedback from the phonological to the lemma level; rather the phonological priming resulted in a word being less accessible, and so the speaker experienced difficulty retrieving a word's phonological form and restructured the sentence.

Given the pattern of results observed in Expt. 7, it may be that feedback from the phonological to the syntactic level would affect the syntactic repetition effect. Given a prime description such as 'the

wheel that's green', the fact that the words 'wheel' and 'whale' shared phoneme segments should result in activation of the word-form 'whale' as well as 'wheel'. According to an interactive account, this will result in feedback of activation to the lemma level from 'whale' to its corresponding lemma WHALE.

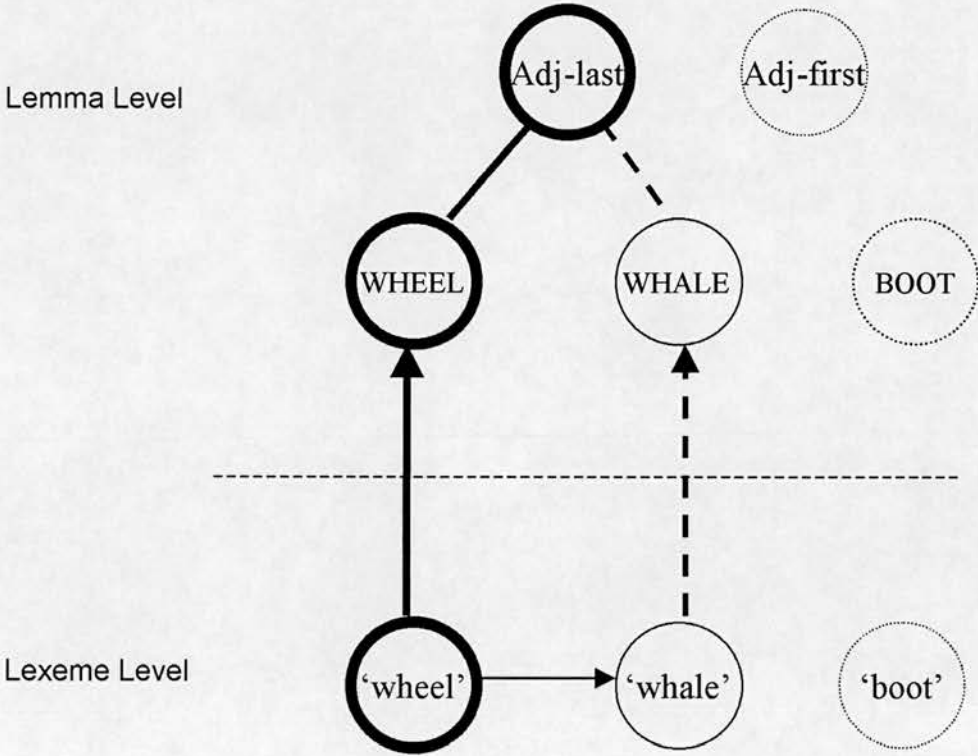


Fig. 20. Possible patterns of activation following a prime such as 'The wheel that's green', given feedback from lexeme to lemma level

Hence, the lemma WHEEL will be highly activated, and the lemma WHALE will also receive a degree of activation relative to an unrelated lemma such as BOOT (see Fig. 20). As the Adj-last combinatorial node is activated as well as the lemma WHALE, there may be a strengthening of the link between them, as in the account proposed for Expt. 7. Hence, on subsequent production of a target description of a green whale, the speaker may be more likely to produce another Adj-last structure than in the case when the target noun is unrelated to the prime. Expt. 8 was designed to test this hypothesis. It manipulated whether

the noun in the confederate prime description was the same, phonologically related, or unrelated to the noun in the target description.

4.7 Experiment Eight

4.7.1 Method

4.7.1.1 Participants

Eighteen participants from the University of Edinburgh community were paid to participate. The data from one further participant was excluded from the analysis due to an extremely high proportion of Other responses.

4.7.1.2 Items

Four sets of cards were prepared. Each set of cards contained 50 different objects, which each appeared in three different colours. The objects were easy to recognise, and could be split into phonologically related pairs: *ball, bell, bar, bear, basket, biscuit, bat, boot, beard, bird, bin, bone, bed, bread, beetle, bottle, beach, bench, bike, book, cap, cup, cat, cot, deer, door, gate, goat, hammer, hamster, hat, hut, horse, house, leg, log, map, mop, mine, moon, sheep, ship, tap, tape, watch, witch, wall, well, whale and wheel*. There were a number of ways in which ‘phonologically related’ could be defined, but in this case phonological overlap was realised primarily through overlapping of initial and final consonants. This meant that the phonologically related prime-target pairs did not share the same vowel; this issue will be returned to in the discussion.

Again, the colours chosen were *red, green* and *pink*. Given that this experiment investigated the effect of phonological overlap between the nouns, it was desirable to avoid phonological overlap between the adjectives and nouns; so, colours which began with the letter ‘b’ were avoided due to the high proportion of nouns which began with ‘b’.

Thirty-six experimental items were constructed (see Appendix). These consisted of a scripted description of one of the cards which would be produced by the confederate, and a target card which the subject would describe on the next trial: e.g.

- 1a. The green wheel
- 1b. The wheel that's green
- 1c. The green whale
- 1d. The whale that's green
- 1e. The green boot
- 1f. The boot that's green
- 2. GREEN WHEEL

So, an experimental item was defined as the confederate's scripted description of the prime card (1a-1f) plus that target card which the subject would subsequently describe. Again, the structure of the prime description could be Adj-first or Adj-last.

The degree of relatedness between prime and target nouns was also manipulated, so the prime noun could be the same as the target noun, or it could be phonologically related, or it could be different. Hence, there were six possible conditions for each experimental item:

- Adj-first prime x same noun
- Adj-last prime x same noun
- Adj-first prime x phonologically related noun
- Adj-last prime x phonologically related noun
- Adj-first prime x different noun
- Adj-last prime x different noun

Six lists of items were constructed in the same way as for Expt. 7, with a set of 36 filler pairs prepared as for Expt. 7 (see Appendix).

4.7.1.3 Procedure

The procedure was similar to Expt. 7. However, the groups of cards were not arranged alphabetically, to avoid phonologically related pairs appearing next to each other on the grid. Instead, the cards were loosely arranged in semantic groups (moon, witch, bear, deer, horse, goat, sheep, cat, hamster, bird, beetle, whale, ship, beach, mine, log, map, house, door, bed, cot, tap, bin, mop, bike, wheel, hut, wall, gate, bench, well, boot, hat, cap, beard, watch, leg, bone, book, ball, bat, bar, hammer, bell, tape, basket, bread, biscuit, bottle and cup).

4.7.1.4 Scoring

As for Expt. 6.

4.7.1.5 Design and Data Analysis

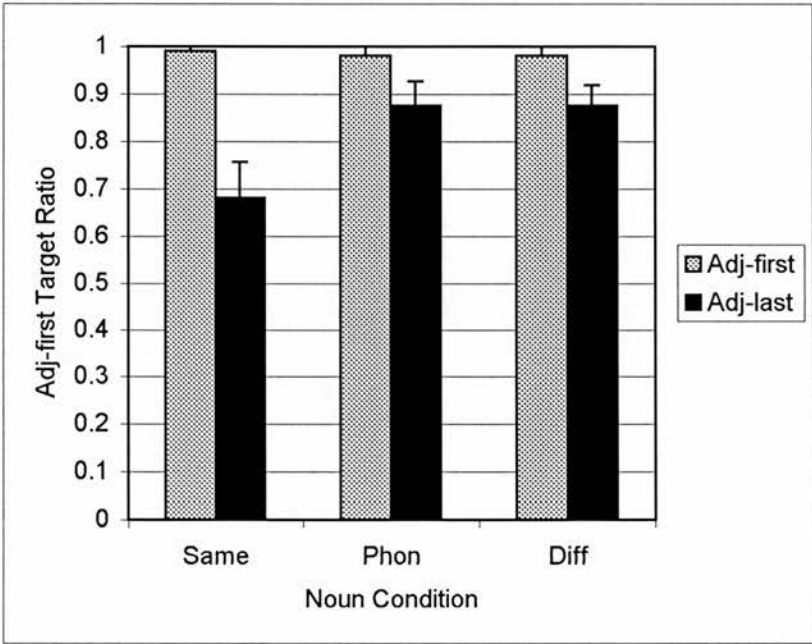
Every participant produced 36 target descriptions, six in each of the six priming conditions defined by the two levels of the Prime Construction factor (Adj-first vs. Adj-last) and three levels of the Noun Condition (Same vs. Phonologically Related vs. Different). Every experimental target was described by all 18 participants, with three participants seeing any one version of an item.

Other responses accounted for three of the target descriptions, 0.5% of the total number of target responses. The Adj-first Target Ratio was calculated as for Experiments 6 and 7.

4.7.2 Results

Fig. 21 reports the Adj-first Target Ratios for the different conditions. ANOVAs on the Adj-first Target Ratio revealed an overall effect of Prime Construction ($F(1,17)=13.06$, $p<.005$, $MSe=.063$; $F(1,35)=85.41$, $p<.001$, $MSe=.019$). Across the experiment, 18% more target utterances were of the same structure as the prime description than were of the alternative. In addition, there was an interaction of Prime Construction by Noun Condition ($F(2,16)=8.61$, $p<.005$, $MSe=.011$; $F(2,34)=10.59$, $p<.001$; $MSe=.021$). When the noun remained the same between prime and target, there was a 31% priming effect, when the prime noun was phonologically related to the target noun, there was an 11% priming effect, and

when the prime noun was unrelated to the target noun, there was also an 11% priming effect. Planned comparisons revealed that there was a significant difference between the priming effect when the noun was repeated and the priming effect in the phonological and different conditions ($F(1,17)=15.91, p<.001, MSe=.016$; $F(1,35)=21.61, p<.001, MSe=.022$) and that there was no difference between the priming effect in the phonologically related and the different conditions ($F(1,17)=.00, p=.99, MSe=.0061$; $F(1,35)=.012, p=.91, MSe=.019$).



Same: Same noun between prime and target; Phon: Phonologically related noun in prime description; Diff: Different nouns between prime and target

Fig. 21. Adj-first Target Ratios for Expt. 8

4.7.3 Discussion

Expt. 8 replicated the finding that experimental participants were significantly more likely to produce a target description with the same structure as the prime description than with the alternative

structure; overall, participants produced 18% more target descriptions of the same structure as the confederate's prime description than of the alternative construction. As in Expts. 6 and 7, the magnitude of this effect was greater when the noun was repeated between prime and target than in the case where it was not (31% priming when the noun was repeated between prime and target versus 11% when it differed). The magnitude of priming when the prime description contained a noun phonologically related to the target noun did not differ from when the prime description contained an noun unrelated to the target description; in other words, phonological relatedness between prime and target nouns did not affect the magnitude of the syntactic repetition effect.

This finding is consistent with the hypothesis that phonological factors do not affect syntactic encoding. Had there been phonological feedback from the word-form to the lemma level, as in an interactive model of language production, an effect of phonology on the magnitude of the syntactic priming effect may have been expected; especially given the semantic effects found in Expt. 7. However, this was not the case. The findings are instead most consistent with a model of production which does not postulate feedback from the word-form to the lemma level (e.g. Levelt et al., 1999).

There are two aspects of the experimental design that should be addressed at this point. The first concerns the type of phonological manipulation. The phonological overlap between prime and target nouns was based on initial and final consonants and hence the vowel differed between the nouns in the prime and target descriptions. It may be that, had a different criteria been used for defining 'phonological relatedness' then a significant result would have been obtained; for example, with pairs of items which rhymed (e.g. 'cat', 'bat') or overlapped on initial phoneme (e.g. 'lamb', 'lamp'). Designing this experiment raised the difficulty of producing pairs of items which were phonologically related, concrete nouns, and easily recognised, and it was in part practical considerations which led to the choice of phonological manipulation. The possibility that other items would have yielded a different result cannot be ruled out on the basis of these results alone. However, it is worth noting that Peterson and Savoy (1998) found effects of phonological overlap in a picture naming task using similar items (e.g. 'lock' and 'luck'; 'ball' and 'bill') so the choice of items was not unreasonable.

A second factor is the timing of the prime-target pairs. There were a few seconds time-lag between the prime and target descriptions; between hearing the prime sentence and producing the target sentence, subjects had to pick out a card from the array in front of them as part of the task. As a result of this, any early effects of phonology would not be reflected in the results. However, as the time-lag was the same as for Expt. 7, this does not change the basic finding of a semantic effect in the absence of a phonological effect. It is still safe to conclude that phonological feedback cannot affect choice of syntactic structure in the same way as semantic factors can; if there are phonological factors at work, they are either too early, or too weak to affect the magnitude of syntactic repetition.

It is not possible to rule out an interactive model of language production on the basis of this data alone; however, it is possible to state that if this feedback does occur, it is not substantial enough to affect syntactic structure in this setting. This issue will be returned to in the General Discussion.

4.8 General Discussion

Using a confederate priming technique, Expts. 6, 7 and 8 were designed to investigate whether syntactic repetition was affected by semantic and phonological factors. The issue of how semantics and phonology affect syntactic encoding in language production is a controversial one (e.g. Dell, 1986; Levelt et al., 1999), with different models postulating varying degrees of interactivity between the different processing stages of language production. Previous studies have found syntactic priming effects for ditransitive and actives and passive structures (e.g. Bock, 1986b; Pickering & Branigan, 1998; Hartsuiker & Kolk, 1998), locative inversions (e.g. Hartsuiker et al., 1999), verb auxiliary order (Hartsuiker & Westenberg, 2000) and coordinate noun phrase structure (Smith & Wheeldon, 2001). The experiments reported here investigated the repetition of noun phrase structures; that is, whether a speaker chose to produce a noun combined with a pre-nominal adjective, or a noun followed by a post-nominal phrase containing the adjective. This extended the finding of syntactic repetition to include another type of structure, and so provided implications for models of how syntactic priming might operate (e.g. Pickering and Branigan, 1998).

All 3 experiments found that the form of subjects' descriptions were significantly influenced by the form of the confederate's immediately preceding prime description. In Expt. 6, 19% more target descriptions were of the same construction as the prime description than were of the alternative; in Expt. 7 there was a 29% priming effect and in Expt. 8, an 18% priming effect. Expt. 6 demonstrated syntactic repetition of noun phrase structures between comprehension and production, and found that this effect was enhanced by lexical overlap (there was a 27% priming effect when the noun was repeated between prime and target descriptions versus 12% when it was different). This finding is consistent with an extension to the Pickering and Branigan (1998) model of the lemma level, where nouns are linked to some kind of information specifying how they might be combined with other units within a noun phrase. The exact nature of how this mechanism might work is not clear; however, for the sake of argument they are envisioned as nodes representing the Adj-first and Adj-last noun phrase constructions. These are analogous to the NP,NP and NP,PP combinatorial nodes corresponding to DO and PO structures postulated by Pickering and Branigan (1998). Syntactic priming would therefore be a consequence of residual activation of these combinatorial nodes. The fact that the repetition effect was enhanced when the noun was repeated between prime and target descriptions suggests that residual activation of the links between nodes might play a role in priming as well as the activation of the nodes themselves. So, when the noun was repeated in a target description, the residual activation of the link between the noun node and the combinatorial node as well as the residual activation of the combinatorial node itself led to repetition of noun phrase structure. This can be contrasted with the case where the prime and target descriptions contained different nouns and the residual activation of the combinatorial information but not the link between the nodes was likely to result in the speaker reusing syntactic structure. Expt. 6 replicated the finding that syntactic priming occurs between interlocutors (Branigan et al., 2000), and is therefore consistent with a model that postulates a shared lemma level between comprehension and production (e.g. Levelt et al., 1999). As argued by Branigan et al., this finding is inconsistent with an account of priming based on residual activation of procedures (e.g. Bock & Loebell, 1990), as while representations might be shared between comprehension and production, procedures are not.

Expt. 7 manipulated whether the noun in the prime description was the same, semantically related, or unrelated to the noun in the target description. The repetition effect was greatest when the noun was repeated between prime and target; however it was also greater when the noun in the prime description was semantically related to the noun in the target description than when it was unrelated (there was a 47% priming effect when the noun was repeated between prime and target, 31% when it was semantically related, and 8% when it was unrelated). The pattern of results indicate that semantic factors are influencing the processes underlying syntactic priming. This finding is interpreted in terms of the Levelt et al. (1999) model of language production where multiple lemmas receive activation from the conceptual level. So, nodes representing lexical concepts at the conceptual level will spread activation to semantically related concepts; for example, activation of the conceptual node for *goat* will result in a degree of activation at the conceptual node for *sheep*. The conceptual nodes activate their corresponding lemma nodes, and so the lemma GOAT will become highly activated, and the lemma SHEEP will become activated to a lesser degree than GOAT but to a greater degree than an unrelated lemma, such as DOOR. Given a prime description such as 'The goat that's red', the combinatorial node corresponding to the Adj-last structure will also become activated. As both the Adj-last node, and the lemma SHEEP are activated, there will be a strengthening of the link between them. Hence, on a subsequent target description of a red goat, a speaker will be more likely to produce an Adj-last description than in a subsequent description of a red knife, as the link between the SHEEP lemma and the Adj-last node is strengthened relative to the link between the DOOR lemma and the Adj-last node (see Fig. 20). This account does not specify exactly how these mechanisms might operate, but it does account for the pattern of results observed in Expt. 7.

Expt. 8 manipulated whether the noun in the confederate's prime description was the same, phonologically related or unrelated to the noun in the target description. As in Expts. 6 and 7, the repetition effect was greatest when the noun remained the same between prime and target (31% priming versus 11% priming when it was different). In addition, Expt. 8 found that the subjects were not more likely to be influenced by the structure of the confederate's prime description when the noun in the prime description was phonologically related to the noun in the target description than when it was unrelated (there was an 11% priming effect in both cases). Phonology did not influence the syntactic priming effect.

Again, the results are interpreted in terms of the model proposed by Levelt et al., where activation feeds forward from the conceptual to the lemma to the word-form level, but does not feed back between these levels. So, activation should not feed back from the word-form to the lemma level. This is consistent with the pattern of results in Expt. 8. However a model which does postulate feed back from the phonological to the lemma level (e.g. Dell, 1986) may predict that phonology would affect syntactic priming. Given that Expt. 7 has already shown that semantics can influence the syntactic priming effect, a model which postulates feedback from the phonological to the lemma level might predict that phonology could also influence the syntactic priming effect. This would occur as lemmas which were phonologically related to each other become activated at the same time. For example, given a prime description such as 'The wheel that's green', the fact that 'wheel' and 'whale' share phonological segments would result in some activation of the word-form for 'whale'. In turn, this activation would feed back to the lemma WHALE. As the lemma WHALE and the Adj-last are both activated, the link between them will be strengthened (see Fig. 20), and so a speaker may have been more likely to use this syntactic structure in a subsequent utterance involving the word 'whale' than an unrelated word (e.g. 'boot'). However, no effect of phonology on the magnitude of priming was observed. The results suggest that if feedback of phonological information does occur, it is too short-lived, or not sufficient to influence syntactic encoding in this situation. Alternatively, it may impact on a stage of language processing which does not involve grammatical role assignments.

There are a number of issues which need to be considered with reference to these experiments. The first is the concern that the apparent syntactic effect was in fact due to the repetition of the words 'that' or 'is'. However, it is difficult to see how an account based purely on lexical repetition could be consistent with the pattern of results observed; the enhanced effect of lexical repetition, and semantic relatedness between prime and target pose particular difficulties for this account.

It is also important to consider the experimental items used in Expts. 7 and 8. Expts. 7 and 8 were quite difficult to prepare experimental items for, as they required pairs of words which were related to each other (semantically in the case of Expt. 7 and phonologically in the case of Expt. 8), and which were both nouns, and which were also easy for subjects to recognise. In Expt. 7 pairs of words which were

'semantically related' had to be members of the same category, rather than just semantic associates, as in a picture-word interference study, Lupker (1979) found no effect of distractors which were only semantically associated with the picture. In Expt. 8, pairs of words which were 'phonologically related' overlapped predominantly in terms of consonants. As Expt. 8 provides a null result, there is a legitimate concern that the lack of an effect of phonology was due to the types of items used rather than due to a real lack of a phonological effect on syntactic processes. This cannot be ruled out on the basis of Expt. 8 alone, and it has to be considered that had a different criterion been used for defining 'phonologically related', another pattern of results would have been obtained. However, Peterson and Savoy (1998) found effects of phonological overlap in a picture naming task using similar items (e.g. 'lock' and 'luck', or 'ball' and 'bill').

The pattern of results found in these experiments has been interpreted in terms of a model of production such as Levelt et al. (1999). However, this is not to say that another model of language production cannot account for the results; an interactive account (e.g. Dell, 1986) is consistent with the pattern of results as long as it does not postulate that phonological feedback is sufficient to affect syntactic repetition, and does hold that multiple lemmas can receive activation from the conceptual level. In addition, while Levelt et al. envision the lemmas as purely syntactic representations, others have suggested that lemmas may in fact be organised according to semantic factors (e.g. Zorzi & Vigliocco, 1999). This is motivated in part by developmental considerations; in this account, lemmas arise as syntactic features are linked onto semantic representations during language development. While this account is not yet clearly defined, it is presumably entirely consistent with the pattern of results observed in Expt. 7 where semantic relatedness increased the magnitude of syntactic priming, as both semantic and syntactic factors would be associated with the lemma level.

A related issue is the fact that the account based on Pickering and Branigan which is used throughout the thesis, is based on the residual activation of nodes and of the "links", or connection weights, between them. A criticism of this account is that it is not particularly economic; it involves the activation of multiple entities, and perhaps a simpler account would be preferable. The hypothesis that activation of links was involved as well as the nodes was based on the observation that the magnitude of

priming is increased by lexical overlap (cf. Chapter 3). Other accounts of priming might be consistent with this observation without resorting to activation of both links and nodes. However, the ‘nodes plus links’ account is neatly consistent with the pattern of results in these dialogue experiments, as outlined above. In addition, the Hebbian reasoning that the connection weights between nodes as well as the nodes themselves should contribute to the overall pattern of activation is not particularly controversial. This approach is only one way of envisioning the brain processes underlying language; however, as a model, it provides a useful and consistent account of the priming data presented here.

Finally, the IN model as proposed by Caramazza et al. (e.g. Caramazza & Miozzo, 1997; Shelton & Caramazza, 1999; see Chapter 3 for a review) may be inconsistent with the finding of priming between comprehension and production. The IN model appears to postulate entirely separate processes for comprehension and production (Shelton & Caramazza, 1999), and given that syntactic information is associated with the word-form level rather than represented at a shared lemma level in the IN model, this would not predict priming between comprehension and production. It may be that the IN model could be consistent with the results by postulating shared syntactic nodes between comprehension and production (cf. Berndt & Haendiges, 2000 for a similar argument with reference to neuropsychological data) but at any rate it appears that the IN model is at present inadequate to account for both the pattern of results observed here, and in Expts. 3, 4 and 5.

4.9 Summary

To summarise, three experiments investigated syntactic repetition of noun phrase structure using the confederate priming technique (Branigan et al., 2000). In addition, the influence of semantic and phonological factors on this repetition was assessed. Across all experiments, speakers were likely to produce noun phrases with the same syntactic structure as the utterance which they had just heard, suggesting that combinatorial information is represented for nouns in a similar manner for verbs and that this information is shared between comprehension and production processes. In addition, semantic relatedness between prime and target nouns enhanced this effect but phonological relatedness did not. The results are interpreted in terms of a model of language production where syntactic information is

represented at a lemma level shared between production and comprehension and where multiple lexical representations receive activation from the semantic level but activation does not feedback from the word-form level of representation (e.g. Levelt et al., 1999).

Chapter 5

Conclusion

This thesis set out to investigate the processing and representation of syntactic information in language production, using syntactic priming (e.g. Bock, 1986b; Pickering & Branigan, 1998). A number of conclusions can be drawn based on the 8 experiments presented here.

The 2 experiments presented in chapter 2 assessed the influence of time pressure on the magnitude of syntactic priming effects. Using a sentence fragment completion technique (Pickering & Branigan, 1998), the experiments demonstrated a syntactic priming effect on ditransitive structures. This effect was larger in magnitude when the verb was repeated between prime and target sentences than when it was not. There was a tendency for the magnitude of priming to be larger when speakers were under time pressure; however this effect was not robust. Overall, speakers were more likely to produce an utterance which was not a ditransitive structure when under time pressure, and these utterances were likely to be shorter than ditransitive sentences. This suggests that the speaker's choice of syntactic structure was affected by time constraints; but probably as a result of them choosing to produce a shorter sentence. While repetition of syntactic structure may facilitate language production to a degree (e.g. Smith & Wheeldon, 2001), speakers placed under time pressure are not more likely to reuse previously processed syntactic structure.

The 3 experiments in chapter 3 were designed to investigate how syntactic information is represented for phonology and orthography. Most models of language production are designed to address spoken language (e.g. Levelt, 1989; Dell, 1986), and do not tend to address the issue of written production. However, a convincing model of language production must provide an account of written output as well as spoken output. It is generally assumed that, in a lemma model of lexical access, the lemma level is a modality neutral layer of representation; syntactic representations are therefore shared between orthography and phonology. Caramazza and colleagues (e.g. Caramazza & Miozzo, 1997; Shelton & Caramazza, 1999) proposed a model of language production (the IN model) which postulated separate processes for written and spoken output. In addition, Caramazza et al. dismissed the concept of

'syntactic mediation'; they rejected the hypothesis that a lemma level intervenes between conceptual and word-form representations. In this model, syntactic information is represented at the same level as the modality specific lexemes.

Expts. 3, 4 and 5 demonstrated that syntactic priming of ditransitive structures occurred between modalities; a spoken prime was as effective as a written prime at priming a written sentence, and a written prime was as effective as a spoken prime in priming a spoken sentence. This suggests that syntactic information is shared between orthography and phonology, and is consistent with a modality neutral lemma model of lexical access (e.g. Levelt et al., 1999). The IN model is consistent with at least a degree of between modality syntactic priming, as it postulates syntactic nodes shared between phonological and orthographic lexemes. However, the nature of these syntactic nodes is ill-defined. On at least one interpretation, the IN model would predict a reduction in the magnitude of priming when prime and target sentences were produced in different modalities. The IN model is not, at present, specified clearly enough to account for the results. Instead, the results are most consistent with a modality neutral lemma level (e.g. Levelt et al., 1999).

The 3 experiments in chapter 4 examined syntactic priming of noun phrase structure. While the experiments in previous chapters examined ditransitive structures, these experiments examined simple noun phrases involving a noun and either a pre-nominal adjective, or a noun followed by a post-nominal phrase involving an adjective. In addition, rather than the production-to-production technique used in chapters 2 and 3, these experiments made use of the confederate priming technique (Branigan, Pickering & Cleland, 2000) to investigate syntactic priming between interlocutors. Expt. 6 found that speakers were influenced by the structure of their dialogue partner's immediately preceding prime description, and that this effect was enhanced by lexical overlap. This was interpreted in terms of a model of the lemma stratum where nouns are linked to combinatorial nodes corresponding to different syntactic structures. Similarly to the account proposed by Pickering and Branigan (1998) to account for syntactic priming effects with verbs, priming arises as a result of residual activation of the combinatorial node, as well as residual activation of the links between the noun node and the combinatorial node. The fact that this effect occurred between interlocutors suggests that syntactic representations are shared between comprehension

and production (cf. Branigan et al., 2000). However, Caramazza and colleagues postulate separate processes for comprehension and production (e.g. Shelton & Caramazza, 1999). It is not clear whether syntactic information is represented separately for comprehension and production in the IN model; however, at present the IN model may be inconsistent with these findings (cf. Berndt & Haendiges, 2000 for a similar criticism).

In Expts. 7 and 8, the degree of semantic and phonological relatedness between prime and target sentences was manipulated. When the noun in the prime sentence was semantically related to the noun in the target sentence, the priming effect was enhanced relative to when it was unrelated. However, phonological relatedness between prime and target had no influence on the priming effect. The results were interpreted in terms of a feedforward model of lexical access (Levelt et al., 1999). According to this model, multiple lemmas receive activation from the conceptual stratum. If a concept such as *sheep* is selected at the conceptual level, semantically related concepts will also receive a degree of activation (e.g. *goat*). Both of these concepts will feed activation forward to their corresponding lemma nodes. The effect of semantic relatedness on the priming effects were accounted for by suggesting that the partial activation of the semantically related word's lemma and the activation of the combinatorial node resulted in a strengthening of the link between them. Hence, on subsequent utterances involving that word, the speaker would be more likely to reuse that structure than when an unrelated word was produced. The fact that phonological relatedness between prime and target nouns did not show a similar effect was taken as evidence that phonology does not affect syntactic encoding. These results were then consistent with a feedforward model of language production (e.g. Levelt et al., 1999).

An interactive model (e.g. Dell, 1986) is consistent with the finding that semantic relatedness between prime and target enhanced priming. This would arise as a result of cascaded activation from the conceptual level; as with the Levelt model, the simultaneous activation of the semantically related lemma and the combinatorial node would result in a strengthening of the link between them. However, the finding that phonology did not affect syntactic choice may be inconsistent with an interactive model of production, as such a model would predict feedback from the phonological to the lemma level. If feedback does occur between these levels, it is either not sufficient or too short-lived to influence syntactic

encoding. Another possibility is that it influences a stage of processing not implicated in grammatical role assignment. At any rate, the results seem most consistent with Levelt et al. (1999).

Based on the pattern of results observed throughout these experiments, it appears that syntactic representations are shared between written and spoken production, and between comprehension and production. Writing and speaking must diverge to some degree in production processes, particularly in articulation; a written word is, of course, different from a spoken word. Similarly, production and comprehension must involve different processes. However, these processes all appear to access the same syntactic representations. The finding that semantic factors influenced syntactic encoding where phonological factors did not is consistent with an account of production where multiple lemmas receive activation from the conceptual level, but activation does not feedback from the phonological to the lemma level. In short, the pattern of results throughout these experiments is most consistent with the Levelt et al. (1999) model of language production.

Appendix

7.1 Chapter 1 Experimental Items7.1.1 Expt. 1 Prime-Target Pairs

Prime

1. The grandmother hands the present / the girl.
2. The driver shows the overalls / the mechanic.
3. The woman sends the form / the company.
4. The secretary sends the invoice / the executive.
5. The millionaire loans the painting / museum.
6. The swimmer loans the towel / the diver.
7. The neighbour lends the mower / the man.
8. The youngster shows the toy / the teacher.
9. The mother gives the toy / the baby.
10. The lecturer gives the book / the professor.
11. The blackmailer sends the photos / the politician.
12. The man sends the money / the bookclub.
13. The student loans the money / the friend.
14. The hairdresser loans the scissors / the assistant.
15. The receptionist lends the key / the trainee.
16. The waiter shows the menu / the hostess.
17. The captain gives the jacket / the sailor.
18. The barman hands the cocktail / the customer.
19. The designer lends the jacket / the model.
20. The assistant hands the bag / the shopper.
21. The father loans the car / the teenager.
22. The builder lends the plans / the surveyor.
23. The coach loans the boots / the footballer.
24. The cricketer shows the ball / the umpire.
25. The fireman gives the blanket / the woman.
26. The farmer gives the shovel / the vet.
27. The courier hands the package / the receptionist.
28. The protestor sends the petition / the MP.
29. The woman sends the donation / the charity.
30. The salesman lends the car / the woman.
31. The nurse shows the chart / the doctor.
32. The artist shows the brush / the critic.
33. The writer gives the manuscript / the publisher.
34. The banker hands the money / the customer.
35. The general hands the medal / the soldier.
36. The reporter sends the article / the editor.
37. The musician loans the violin / the conductor.
38. The lawyer shows the evidence / the jury.
39. The child sends the picture / the grandfather.
40. The journalist shows the photos / the photographer.
41. The chef gives the plate / the waiter.
42. The cowboy gives the guns / the indian.
43. The diplomat hands the documents / the spy.
44. The boy lends the football / the thug.
45. The teacher loans the calculator / the pupil.
46. The pensioner lends the book / the daughter.

Target

- The magician hands.
 The executive shows.
 The boyfriend sends.
 The butler sends.
 The girl loans.
 The welder loans.
 The actor lends.
 The patient shows.
 The florist gives.
 The policeman gives.
 The sailor sends.
 The coroner sends.
 The teenager loans.
 The rancher loans.
 The climber lends.
 The detective shows.
 The shopkeeper gives.
 The surgeon hands.
 The wife lends.
 The soldier hands.
 The carpenter loans.
 The forester lends.
 The schoolboy loans.
 The servant shows.
 The bus driver gives.
 The researcher gives.
 The dancer hands.
 The fan sends.
 The supervisor sends.
 The gardener lends.
 The jeweller shows.
 The cook shows.
 The air-hostess gives.
 The teenager hands.
 The detective hands.
 The landlord sends.
 The draftsman loans.
 The painter shows.
 The bank sends.
 The criminal shows.
 The librarian gives.
 The zookeeper gives.
 The waitress hands.
 The gangster lends.
 The explorer loans.
 The accountant lends.

47. The minister lends the bible / the woman.
48. The nurse hands the scalpel / the surgeon.

The milkman lends.
The pupil hands.

7.1.2 Expt. 2 Prime-Target Pairs

Prime

1. The mother gives the toy / the baby.
2. The lecturer gives the book / the professor.
3. The captain gives the jacket / the sailor.
4. The fireman gives the blanket / the woman.
5. The farmer gives the shovel / the vet.
6. The writer gives the manuscript / the publisher.
7. The chef gives the plate / the waiter.
8. The cowboy gives the guns / the indian.
9. The grandmother hands the present / the girl.
10. The barman hands the cocktail / the customer.
11. The assistant hands the bag / the shopper.
12. The courier hands the package / the receptionist.
13. The banker hands the money / the customer.
14. The general hands the medal / the soldier.
15. The diplomat hands the documents / the spy.
16. The nurse hands the scalpel / the surgeon.
17. The woman sends the form / the company.
18. The secretary sends the invoice / the executive.
19. The blackmailer sends the photos / the politician.
20. The man sends the money / the bookclub.
21. The protestor sends the petition / the MP.
22. The woman sends the donation / the charity.
23. The reporter sends the article / the editor.
24. The child sends the picture / the grandfather.
25. The millionaire loans the painting / the museum.
26. The swimmer loans the towel / the diver.
27. The student loans the money / the friend.
28. The hairdresser loans the scissors / the assistant.
29. The father loans the car / the teenager.
30. The coach loans the boots / the footballer.
31. The musician loans the violin / the conductor.
32. The teacher loans the calculator / the pupil.
33. The neighbour lends the mower / the man.
34. The receptionist lends the key / the trainee.
35. The designer lends the jacket / the model.
36. The builder lends the plans / the surveyor.
37. The salesman lends the car / the woman.
38. The boy lends the football / the thug.
39. The pensioner lends the book / the daughter.
40. The minister lends the bible / the woman.
41. The driver shows the overalls / the mechanic.
42. The youngster shows the toy / the teacher.
43. The cricketer shows the ball / the umpire.
44. The nurse shows the chart / the doctor.
45. The artist shows the brush / the critic.
46. The lawyer shows the evidence / the jury.
47. The journalist shows the photos / the photographer.

Target

The magician hands.
The executive shows.
The boyfriend sends.
The butler sends.
The girl loans.
The welder loans.
The actor lends.
The patient shows.
The florist gives.
The policeman gives.
The sailor sends.
The coroner sends.
The teenager loans.
The rancher loans.
The climber lends.
The detective shows.
The shopkeeper gives.
The surgeon hands.
The wife lends.
The soldier hands.
The carpenter loans.
The forester lends.
The schoolboy loans.
The servant shows.
The bus driver gives.
The researcher gives.
The dancer hands.
The fan sends.
The supervisor sends.
The gardener lends.
The jeweller shows.
The cook shows.
The air-hostess gives.
The teenager hands.
The detective hands.
The landlord sends.
The draftsman loans.
The painter shows.
The bank sends.
The criminal shows.
The librarian gives.
The zookeeper gives.
The waitress hands.
The gangster lends.
The explorer loans.
The accountant lends.
The milkman lends.

48. The waiter shows the menu / the hostess.

The pupil hands.

7.1.3 Expt. 1 & Expt. 2 Filler Sentence Fragments

1. The woman advises the journalist.
2. The negotiator persuades the kidnapper.
3. The colonel.
4. The teenager.
5. The journalist persuades.
6. The assistant.
7. The stuntman.
8. The director urges the actors.
9. The teacher urges.
10. The disabled motorist.
11. The sailor.
12. The father reminds the child.
13. The student convinces.
14. The witness.
15. The marine.
16. The manager persuades the band.
17. The general urges.
18. The farmer.
19. The councillor.
20. The boy convinces the grandmother.
21. The mother reminds.
22. The lawyer convinces the jury.
23. The lecturer.
24. The swimmer.
25. The scientist advises.
26. The pupil asks the class.
27. The DJ.
28. The librarian reminds.
29. The politician persuades the public.
30. The tourist asks the guide.
31. The secretary.
32. The youngster.
33. The scriptwriter asks.
34. The diplomat advises the government.
35. The terrorist.
36. The editor.
37. The protestor urges.
38. The hostess asks the guests.
39. The gypsy.
40. The hiker.
41. The rabbi persuades.
42. The man persuades the reporter.
43. The pensioner.
44. The architect.
45. The lawyer convinces.
46. The gymnast.
47. The teacher advises.
48. The attorney advises the company.
49. The defendant.

50. The genius.
51. The foreman reminds.
52. The policeman reminds the suspect.
53. The footballer.
54. The engineer.
55. The mayor convinces.
56. The rescuer urges the climbers.
57. The musician.
58. The programmer.
59. The economist advises.
60. The artist.
61. The pianist.
62. The supervisor reminds the worker.
63. The colonel asks.
64. The landlord.
65. The grandparent.
66. The presenter asks.
67. The nurse urges the patient.
68. The singer.
69. The teenager persuades.
70. The cartoonist asks.
71. The presenter asks the politician.
72. The fireman.
73. The prophet persuades the people.
74. The novelist persuades.
75. The trucker.
76. The cleaner reminds the manager.
77. The producer reminds.
78. The rambler.
79. The inspector advises the chef.
80. The actress advises.
81. The model.
82. The agent urges the actress.
83. The visitor urges.
84. The clown.
85. The athlete urges the presenter.
86. The pirate urges.
87. The walker.
88. The decorator asks the housewife.
89. The policeman asks.
90. The suspect.
91. The carer persuades the family.
92. The interviewee persuades.
93. The binman.
94. The visitor asks the farmer.
95. The blacksmith asks.
96. The therapist.
97. The butler reminds the servant.
98. The miner reminds.
99. The chemist.
100. The chemist advises the pensioner.
101. The therapist advises.
102. The viking.
103. The cowboy convinces the sheriff.

104. The footballer convinces.
105. The skater.
106. The tourist.
107. The musician.
108. The fireman.
109. The lifeguard.
110. The housewife.
111. The bookie urges the gambler.
112. The criminal urges.
113. The jockey.
114. The engineer asks the welder.
115. The workman asks.
116. The judge.
117. The singer convinces the manager.
118. The fireman convinces.
119. The sniper.
120. The newsreader convinces the viewers.
121. The gardener convinces.
122. The astrologer.
123. The psychic advises the teenager.
124. The physicist advises.
125. The prisoner.
126. The champion convinces the commentator.
127. The stuntman convinces.
128. The optician.
129. The sculptor.
130. The attorney.
131. The tutor.
132. The typist.
133. The magician reminds the assistant.
134. The executive reminds.
135. The fisherman.
136. The cabby advises the passenger.
137. The editor advises.
138. The priest.
139. The bandit urges the villagers.
140. The guitarist urges.
141. The pianist.
142. The filmstar convinces the director.
143. The pilot convinces.
144. The warden.
145. The cashier asks the customer.
146. The gymnast asks.
147. The barber.
148. The clubbers persuade the bouncer.
149. The hairdresser persuades.
150. The janitor.
151. The optician asks the customer.
152. The author asks.
153. The baker.
154. The barmaid reminds the customer.
155. The hacker reminds.
156. The pilot.
157. The scientist advises the astronaut.

158. The solicitor advises.
159. The landlord.
160. The unionist urges the voters.
161. The judge urges.
162. The undertaker.
163. The agent convinces the client.
164. The plumber convinces.
165. The electrician.
166. The politician reminds the voters.
167. The nurse reminds.
168. The reviewer.
169. The acrobat.
170. The weaver.
171. The butcher.
172. The milkman.
173. The officer.
174. The comedian.
175. The hotelier persuades the guests.
176. The electrician persuades.
177. The ballerina.
178. The bandit asks the tourist.
179. The skier asks.
180. The navigator.
181. The woman reminds the smoker.
182. The referee reminds.
183. The bachelor.
184. The caddie asks the golfer.
185. The beggar asks.
186. The busker.
187. The minister urges the congregation.
188. The cleaner urges.
189. The dentist.
190. The dentist convinces the man.
191. The composer convinces.
192. The magistrate.

7.2 Chapter 3 Experimental Items

7.2.1 Expt. 3 & Expt. 5 Prime-Target Pairs

Prime

1. The woman sends the form/company.
2. The blackmailer sends the photos/MP.
3. The man sends the donation/charity.
4. The child sends the picture/grandfather.
5. The mother gives the toy/baby.
6. The lecturer gives the book/student.
7. The writer gives the script/publisher.
8. The cowboy gives the guns/indian.
9. The cricketer shows the ball/umpire.
10. The youngster shows the toy/teacher.
11. The nurse shows the chart/doctor.
12. The lawyer shows the evidence/jury.

Target

- The boyfriend sends.
- The sailor sends.
- The fan sends.
- The writer sends.
- The bus driver gives.
- The zoo keeper gives.
- The shop assistant gives.
- The air-hostess gives.
- The child shows.
- The patient shows.
- The jeweller shows.
- The artist shows.

13. The millionaire loans the painting/museum.
14. The swimmer loans the towel/diver.
15. The father loans the car/daughter.
16. The hairdresser loans the scissors/assistant.
17. The neighbour lends the mower/friend.
18. The builder lends the plans/surveyor.
19. The salesman lends the car/woman.
20. The designer lends the jacket/model.
21. The barman hands the pint/customer.
22. The courier hands the package/receptionist.
23. The assistant hands the bag/shopper.
24. The nurse hands the scalpel/dentist.

The musician loans.
 The teenager loans.
 The student loans.
 The banker loans.
 The cook lends.
 The trainee lends.
 The wife lends.
 The driver lends.
 The surgeon hands.
 The waitress hands.
 The soldier hands.
 The newsagent hands.

7.2.2 Expt. 4 Prime-Target Pairs

Prime

1. The mother gives the toy/baby.
2. The cricketer shows the ball/umpire.
3. The millionaire loans the painting/museum.
4. The neighbour lends the mower/friend.
5. The barman hands the pint/customer.
6. The woman sends the form/company.
7. The youngster shows the toy/teacher.
8. The swimmer loans the towel/diver.
9. The builder lends the plans/surveyor.
10. The courier hands the package/receptionist.
11. The blackmailer sends the photos/MP.
12. The lecturer gives the book/student.
13. The nurse shows the chart/doctor.
14. The salesman lends the car/woman.
15. The assistant hands the bag/shopper.
16. The man sends the donation/charity.
17. The writer gives the script/publisher.
18. The lawyer shows the evidence/jury.
19. The father loans the car/daughter.
20. The nurse hands the scalpel/dentist.
21. The child sends the picture/grandfather.
22. The cowboy gives the gun/indian.
23. The hairdresser loans the scissors/assistant.
24. The designer lends the jacket/model.

Target

The boyfriend sends.
 The sailor sends.
 The fan sends.
 The writer sends.
 The bus driver gives.
 The zoo keeper gives.
 The shop assistant gives.
 The air-hostess gives.
 The child shows.
 The patient shows.
 The jeweller shows.
 The artist shows.
 The musician loans.
 The teenager loans.
 The student loans.
 The banker loans.
 The cook lends.
 The trainee lends.
 The wife lends.
 The driver lends.
 The surgeon hands.
 The waitress hands.
 The soldier hands.
 The newsagent hands.

7.2.3 Expts 3, 4 & 5 Filler Sentence Fragments

1. The butler reminds the servant
2. The bookie urges the gambler
3. The colonel
4. The teenager
5. The fireman persuades
6. The assistant
7. The stuntman
8. The director urges the actors
9. The teacher urges

10. The disabled motorist
11. The sailor
12. The father reminds the child
13. The student convinces
14. The witness
15. The marine
16. The manager persuades the band
17. The general urges
18. The farmer
19. The councillor
20. The boy convinces the grandmother
21. The mother reminds
22. The lawyer convinces the jury
23. The lecturer
24. The swimmer
25. The scientist advises
26. The pupil asks the class
27. The DJ
28. The librarian reminds
29. The politician persuades the public
30. The tourist asks the guide
31. The secretary
32. The youngster
33. The scriptwriter asks
34. The diplomat advises the government
35. The terrorist
36. The editor
37. The protester urges
38. The hostess asks the guests
39. The gypsy
40. The hiker
41. The rabbi persuades
42. The man persuades the reporter
43. The pensioner
44. The architect
45. The lawyer convinces
46. The gymnast
47. The teacher advises
48. The attorney advises the company
49. The defendant
50. The genius
51. The foreman reminds
52. The policeman reminds the suspect
53. The footballer
54. The engineer
55. The mayor convinces
56. The rescuer urges the climbers
57. The musician
58. The programmer
59. The economist advises
60. The artist
61. The pianist
62. The barmaid reminds the man
63. The colonel asks

64. The landlord
65. The grandparent
66. The presenter asks
67. The nurse urges the patient
68. The singer
69. The teenager persuades
70. The cartoonist asks
71. The woman asks the smoker
72. The fireman
73. The prophet persuades the people
74. The novelist persuades
75. The trucker
76. The cleaner reminds the manager
77. The producer reminds
78. The rambler
79. The inspector advises the chef
80. The actress advises
81. The model
82. The agent urges the actress
83. The visitor urges
84. The clown
85. The athlete urges the presenter
86. The pirate urges
87. The walker
88. The agent asks the client
89. The policeman asks
90. The suspect
91. The carer persuades the family
92. The interviewee persuades
93. The binman
94. The visitor asks the farmer
95. The blacksmith asks
96. The therapist

7.3 Chapter 4 Experimental Items

7.3.1 Expt. 6 Prime-Target Pairs

Stooge

1. Red square / red diamond / green square / green diamond.
2. Green diamond / green square / red diamond / red square.
3. Blue triangle / blue club / orange triangle / orange club.
4. Orange club / orange triangle / blue club / blue triangle.
5. Red moon / red ring / brown moon / brown ring.
6. Brown ring / brown moon / red ring / red moon.
7. Black circle / black spade / purple circle / purple spade.
8. Purple spade / purple circle / black spade / black circle.
9. Yellow sun / yellow heart / pink sun / pink heart.
10. Pink heart / pink sun / yellow heart / yellow sun.
11. Green rectangle / green oval / blue rectangle / blue oval.
12. Blue oval / blue rectangle / green oval / green rectangle.
13. Grey star / grey cross / brown star / brown cross.
14. Brown cross / brown star / grey cross / grey star.

Subject

- Red square
- Green diamond
- Blue triangle
- Orange club
- Red moon
- Brown ring
- Black circle
- Purple spade
- Yellow sun
- Pink heart
- Green rectangle
- Blue oval
- Grey star
- Brown cross

| | |
|--------------------------------------------------------------------|------------------|
| 15. Yellow circle / yellow triangle / red circle / red triangle. | Yellow circle |
| 16. Red triangle / red circle / yellow triangle / yellow circle. | Red triangle |
| 17. Orange arrow / orange moon / pink arrow / pink moon. | Orange arrow |
| 18. Pink moon / pink arrow / orange moon / orange arrow. | Pink moon |
| 19. Green club / green spade / pink club / pink spade. | Green club |
| 20. Pink spade / pink club / green spade / green club. | Pink spade |
| 21. Blue sun / blue star / black sun / black star. | Blue sun |
| 22. Black star / black sun / blue star / blue sun. | Black star |
| 23. Black ring / black oval / purple ring / purple oval. | Black ring |
| 24. Purple oval / purple ring / black oval / black ring. | Purple oval |
| 25. Orange heart / orange cross / purple heart / purple cross. | Orange heart |
| 26. Purple cross / purple heart / orange cross / orange heart. | Purple cross |
| 27. Grey square / grey diamond / brown square / brown diamond. | Grey square |
| 28. Brown diamond / brown square / grey diamond / grey square. | Brown diamond |
| 29. Yellow rectangle / yellow arrow / grey rectangle / grey arrow. | Yellow rectangle |
| 30. Grey arrow / grey rectangle / yellow arrow / yellow rectangle. | Grey arrow |
| 31. Blue square / blue circle / pink square / pink circle. | Blue square |
| 32. Pink circle / pink square / blue circle / blue square. | Pink circle |
| 33. Orange diamond / orange sun / purple diamond / purple sun. | Orange diamond |
| 34. Purple sun / purple diamond / orange sun / orange diamond. | Purple sun |
| 35. Orange rectangle / orange oval / pink rectangle / pink oval. | Orange rectangle |
| 36. Pink oval / pink rectangle / orange oval / orange rectangle. | Pink oval |
| 37. Black triangle / black heart / grey triangle / grey heart. | Black triangle |
| 38. Grey heart / grey triangle / black heart / black triangle. | Grey heart |
| 39. Purple club / purple star / red club / red star. | Purple club |
| 40. Red star / red club / purple star / purple club. | Red star |
| 41. Green ring / green arrow / blue ring / blue arrow. | Green ring |
| 42. Blue arrow / blue ring / green arrow / green ring. | Blue arrow |
| 43. Black square / black club / yellow square / yellow club. | Black square |
| 44. Yellow club / yellow square / black club / black square. | Yellow club |
| 45. Grey circle / grey spade / brown circle / brown spade. | Grey circle |
| 46. Brown spade / brown circle / grey spade / grey circle. | Brown spade |
| 47. Black moon / black rectangle / purple moon / purple rectangle. | Black moon |
| 48. Purple rectangle / purple moon / black rectangle / black moon. | Purple rectangle |

7.3.2 Expt. 6 Filler Pairs

| Stooge | Subject |
|--------------------|----------------|
| 1. Orange square | Red club |
| 2. Purple square | Green triangle |
| 3. Blue diamond | Orange star |
| 4. Black diamond | Blue spade |
| 5. Yellow diamond | Black cross |
| 6. Pink diamond | Purple square |
| 7. Green triangle | Yellow diamond |
| 8. Purple triangle | Pink sun |
| 9. Pink triangle | Grey diamond |
| 10. Brown triangle | Red circle |
| 11. Grey club | Brown heart |
| 12. Brown club | Green sun |
| 13. Green circle | Blue club |
| 14. Orange circle | Black spade |
| 15. Red spade | Orange square |

| | |
|------------------|-----------------|
| 16. Blue spade | Purple triangle |
| 17. Orange spade | Yellow heart |
| 18. Yellow spade | Pink star |
| 19. Red sun | Grey cross |
| 20. Green sun | Brown circle |
| 21. Grey sun | Red diamond |
| 22. Brown sun | Green square |
| 23. Red heart | Blue circle |
| 24. Green heart | Orange triangle |
| 25. Blue heart | Black sun |
| 26. Brown heart | Purple star |
| 27. Green star | Pink club |
| 28. Orange star | Grey spade |
| 29. Yellow star | Brown square |
| 30. Pink star | Red heart |
| 31. Red cross | Green circle |
| 32. Green cross | Blue heart |
| 33. Black cross | Orange spade |
| 34. Yellow cross | Black club |
| 35. Pink cross | Purple diamond |
| 36. Blue cross | Yellow triangle |
| 37. Green moon | Red spade |
| 38. Blue moon | Green heart |
| 39. Yellow moon | Blue diamond |
| 40. Grey moon | Orange circle |
| 41. Orange ring | Black heart |
| 42. Yellow ring | Purple circle |
| 43. Red bar | Grey sun |
| 44. Brown bar | Red arrow |
| 45. Yellow oval | Green spade |
| 46. Grey oval | Blue moon |
| 47. Purple arrow | Yellow oval |
| 48. Black arrow | Purple heart |

7.3.3 Expt. 7 Prime-Target Pairs

Stooge

1. Red sheep / red goat / red knife
2. Green fork / green knife / green dog
3. Pink dog / pink cat / pink skirt
4. Red tiger / red lion / red banjo
5. Green wolf / green fox / green bed
6. Pink shark / pink whale / pink tree
7. Red spider / red beetle / red guitar
8. Green watch / green clock / green mop
9. Pink star / pink moon / pink fence
10. Red tree / red bush / red boot
11. Green axe / green saw / green cup
12. Pink goose / pink duck / pink dress
13. Red foot / red hand / red bus
14. Green shoe / green boot / green cheese
15. Pink glass / pink cup / pink sheep
16. Red leg / red arm / red cap

Subject

- Red sheep
- Green fork
- Pink dog
- Red tiger
- Green wolf
- Pink shark
- Red spider
- Green watch
- Pink star
- Red tree
- Green axe
- Pink goose
- Red foot
- Green shoe
- Pink glass
- Red leg

| | |
|-----------------------------------------------|-------------|
| 17. Green dress / green skirt / green cat | Green dress |
| 18. Pink brush / pink mop / pink goat | Pink brush |
| 19. Red plate / red bowl / red wolf | Red plate |
| 20. Green train / green bus / green glass | Green train |
| 21. Pink hat / pink cap / pink bush | Pink hat |
| 22. Red cheese / red bread / red fox | Red cheese |
| 23. Green banjo / green guitar / green spider | Green banjo |
| 24. Pink bed / pink cot / pink clock | Pink bed |
| 25. Red fence / red gate / red train | Red fence |
| 26. Green goat / green sheep / green brush | Green goat |
| 27. Pink lion / pink tiger / pink guitar | Pink lion |
| 28. Red whale / red shark / red fork | Red whale |
| 29. Green moon / green star / green cot | Green moon |
| 30. Pink knife / pink fork / pink watch | Pink knife |
| 31. Red duck / red goose / red dress | Red duck |
| 32. Green arm / green leg / green bread | Green arm |
| 33. Pink bus / pink train / pink wolf | Pink bus |
| 34. Red cot / red bed / red glass | Red cot |
| 35. Green cap / green hat / green shark | Green cap |
| 36. Pink bread / pink cheese / pink fox | Pink bread |

7.3.4 Expt. 7 Filler Pairs

| Stooge | Subject |
|------------------|--------------|
| 1. Red dog | Green cup |
| 2. Red cat | Pink train |
| 3. Red watch | Green plate |
| 4. Red clock | Pink foot |
| 5. Red star | Green hand |
| 6. Red moon | Pink cheese |
| 7. Red cup | Green shark |
| 8. Red skirt | Pink sheep |
| 9. Red mop | Green dog |
| 10. Red brush | Pink whale |
| 11. Red hat | Green lion |
| 12. Red shoe | Pink tree |
| 13. Green lion | Red skirt |
| 14. Green tiger | Pink mop |
| 15. Green whale | Red hat |
| 16. Green beetle | Pink shoe |
| 17. Green tree | Red bread |
| 18. Green duck | Pink arm |
| 19. Green goose | Red bus |
| 20. Green hand | Pink tiger |
| 21. Green foot | Red moon |
| 22. Green plate | Pink spider |
| 23. Green gate | Red cat |
| 24. Green fence | Pink duck |
| 25. Pink hand | Red wolf |
| 26. Pink foot | Green beetle |
| 27. Pink arm | Red goose |
| 28. Pink leg | Green tree |
| 29. Pink bowl | Red watch |

| | |
|-----------------|-------------|
| 30. Pink banjo | Green duck |
| 31. Pink beetle | Red gate |
| 32. Pink spider | Green fence |
| 33. Pink axe | Red dress |
| 34. Pink saw | Green bed |
| 35. Pink boot | Red dog |
| 36. Pink shoe | Green knife |

7.3.5 Expt. 8 Prime-Target Pairs

Stooge

1. Red bell / Red ball / Red horse
2. Pink horse / Pink house / Pink wall
3. Green wall / Green well / Green cot
4. Red book / Red bike / Red wheel
5. Green wheel / Green whale / Green boot
6. Pink sheep / Pink ship / Pink ball
7. Pink door / Pink deer / Pink bird
8. Green bone / Green bin / Green mop
9. Pink mop / Pink map / Pink bear
10. Red beetle / Red bottle / Red hammer
11. Green bear / Green bar / Green hat
12. Pink hat / Pink hut / Pink bread
13. Green bed / Green bread / Green watch
14. Red watch / Red witch / Red bird
15. Pink hammer / Pink hamster / Pink basket
16. Green bird / Green beard / Green cup
17. Red bench / Red beach / Red log
18. Pink cup / Pink cap / Pink beard
19. Green log / Green leg / Green bench
20. Red basket / Red biscuit / Red hamster
21. Pink tap / Pink tape / Pink bell
22. Red gate / Red goat / Red mine
23. Green moon / Green mine / Green cat
24. Pink cat / Pink cot / Pink bike
25. Red boot / Red bat / Red ship
26. Green ball / Green bell / Green hut
27. Red well / Red wall / Red house
28. Green bike / Green book / Green horse
29. Pink whale / Pink wheel / Pink book
30. Red cot / Red cat / Red whale
31. Pink bat / Pink boot / Pink well
32. Green ship / Green sheep / Green bat
33. Green deer / Green door / Green map
34. Pink bin / Pink bone / Pink goat
35. Green bottle / Green beetle / Green hammer
36. Red map / Red mop / Red sheep

Subject

Red bell
 Pink horse
 Green wall
 Red book
 Green wheel
 Pink sheep
 Pink door
 Green bone
 Pink mop
 Red beetle
 Green bear
 Pink hat
 Green bed
 Red watch
 Pink hammer
 Green bird
 Red bench
 Pink cup
 Green log
 Red basket
 Pink tap
 Red gate
 Green moon
 Pink cat
 Red boot
 Green ball
 Red well
 Green bike
 Pink whale
 Red cot
 Pink bat
 Green ship
 Green deer
 Pink bin
 Green bottle
 Red map

7.3.6 Expt. 8 Filler Pairs

Stooge

1. Red door

Subject

Green bell

- | | |
|-------------------|---------------|
| 2. Red deer | Pink ball |
| 3. Red bone | Green horse |
| 4. Red bin | Pink wall |
| 5. Red bear | Green cat |
| 6. Red bar | Pink bike |
| 7. Red hat | Green whale |
| 8. Red hut | Pink ship |
| 9. Red bed | Green beetle |
| 10. Red bread | Pink bottle |
| 11. Red beard | Green hat |
| 12. Red cup | Pink bed |
| 13. Red cap | Green witch |
| 14. Red leg | Pink watch |
| 15. Pink gate | Green book |
| 16. Pink mine | Red beard |
| 17. Pink moon | Green watch |
| 18. Green house | Pink log |
| 19. Green witch | Red tap |
| 20. Green hamster | Pink goat |
| 21. Green beach | Red mine |
| 22. Green cap | Pink moon |
| 23. Green basket | Red horse |
| 24. Green biscuit | Pink gate |
| 25. Green tap | Red door |
| 26. Green tape | Pink deer |
| 27. Green goat | Red bear |
| 28. Green gate | Pink bird |
| 29. Pink beetle | Red hammer |
| 30. Pink bottle | Green hamster |
| 31. Pink bar | Red bone |
| 32. Pink bed | Green sheep |
| 33. Pink watch | Red moon |
| 34. Pink witch | Green gate |
| 35. Pink beach | Red hat |
| 36. Pink bench | Green mop |

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